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## MODERNIZING WITH MODERN MATERIALS

POWERFUL forces are at work for business recovery and in nearly every direction there is evidence of some improvement. This is not alone in sentiment but also in the very encouraging form of increased employment, particularly in the plants that make consumer goods. Yet if the present revival is to have a real measure of permanence, it is becoming increasingly apparent that activity must also be stimulated in the great industries that produce our capital goods-tools, machinery and equipment. That stimulus must come from those industries which during the past three years have failed to maintain their plants at maximum efficiency, presumably because they have postponed the normal purchasing of new equipment. In other words, if we are to have true reconstruction in this country, a broad program of industrial modernization must shortly get under way.

It goes without saying that industries will not be rehabilitated for purely altruistic purposes. Self interest will continue to dictate. But in the great readjustment of values that characterizes today's business, it is equally obvious that no manufacturer can hope to compete if handicapped by obsolete processes and equipment. Modernization is the only way out if profits are to come from lower costs on a reduced volume of business.

In chemical industry, the most striking trend

of modernization is in the utilization of new materials for chemical engineering construction. Technical progress, born and reared in laboratory during the past three years of diligent research, demands resourceful engineering in plant design and equipment fabrication. Increasingly severe conditions in the processing of corrosive chemicals at high temperatures and pressures call for greatly improved materials. Fortunately, the manufacturers have kept pace with the chemical engineer's progress so that today new corrosion-resisting metals, alloys, plastics, glass, rubber and other modern materials are readily available for practically every type of chemical application. The stage is set for a widespread and thorough program of modernization in the process industries.

In this issue of *Chem. & Met.*—the fifth in a distinguished series to deal exclusively with materials of construction—the editors have approached their task with a single purpose in mind, namely, to reflect and record in the most concise and convenient form the many new and useful developments in the field of corrosion resistance. The pages that follow offer convincing proof that modern materials are at hand with which the chemical engineer can build for the future, safely and profitably. Chemical industry, "never built but always building," can be counted on to do its share in the national program of reconstruction.

# CHOOSING AND USING MATERIALS FOR CHEMICAL PLANT

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**S**ELECTION of proper materials for the construction of chemical plant equipment is one of the most important and often one of the most difficult functions of the chemical engineer. Combining as it does interrelated factors of economics and technology, it is capable of rigorous solution only after intensive investigation of an ever increasing array of materials, both metallic and non-metallic. From this now vast field the engineer must test, examine and weigh the advantages of one material against another, with the ultimate aim of choosing only those which effect the best possible compromise with the requirements, yielding the best possible product at the lowest possible total cost.

Admittedly, the problem is often much simpler than this would make it appear, especially in the case of products of more or less standardized technology, but even here it is frequently unsafe to assume that old methods should be retained.

A determined skepticism should be one of the outstanding characteristics of the engineer bent on ferreting out corrosion-resisting materials. One of his first principles is that things are not always as they seem and that slight changes in operating conditions, small variations in concentration or temperature, minute quantities of impurities in the reaction fluids or in the construction materials, may completely invalidate earlier results. A material is never proved satisfactory until it has been proved in actual operation, under the exact conditions of use. Analogous cases may be of great assistance in the elimination of patently unsuited materials and in directing the course of investigations, but they can rarely be relied upon without further check.

Obviously, it is impossible in the

space available here to more than adumbrate the philosophy of materials choice, but there should be no great obstacle in the way of developing a logical scheme for at least a part of the question. The exact procedure to be followed will, of course, depend on circumstances, but the principles outlined should provide a groundwork for the practical elimination of guesswork. Chemical engineering, applied with patience and interpreted with the aid of experience, common sense and the ability to weigh both economic and technical considerations, constitutes the method as it does in any chemical engineering problem.

Roughly, there will be three stages in any materials investigation: the elimination of materials that are obviously unfit; the revaluation of apparently satisfactory materials; and, lastly, the interpretation of results and the final selection (and sometimes the rechecking) of a single material or group of materials. Through these three stages, the possible materials pass in review, unsuitable ones being eliminated as rapidly as possible until the list has been reduced to the one material or group of materials best suited to the intended applications.

## Elimination of Obviously Unfit Materials

In the first stage, engineering judgment and the literature are at the same time the sources of data and the criteria on which the earlier eliminations are based. Starting with the two or three thousand materials of structural significance, the engineer can immediately eliminate all but a comparatively small group. Perhaps experience will delineate the group sufficiently to make a search of the literature unnecessary.

Otherwise, the search is the next step. In any event, however, bearing in mind the fact that information in the literature may not represent truly parallel conditions, it is a good rule to make a simpler rather than a more thorough search since it will probably be necessary to confirm anything that may be uncovered.

In the order in which it is advisable to examine them are: (1) published lists of materials and their physical and chemically resistant properties, such as those compiled by *Chem. & Met.* and the American Society for Testing Materials; (2) manufacturers' data; and (3) books such as those of Speller; Calcott, Whetzel and Whittaker; U. R. Evans; Monypenny; Hamlin and Turner; and certain of the thorough-going German compilations such as those of Fürth and Rabald. Only as a last resort is it recommended to go to the non-specific literature, which, in case of necessity may be approached by way of the abstract journals, literature indices and bibliographies, such as the "Bibliography of Metallic Corrosion" of Vernon (Arnold, London, 1928).

This sifting process should reduce the number of materials under consideration to from two to ten or more, none of which has been shown definitely to be unsuitable on the basis of information at hand. From the standpoint of corrosion resistance alone, the list may be much larger, but for obvious reasons, it should be made as narrow as possible, consistent with the retention of those materials which appear to offer the best possibilities. Availability should consequently be taken into consideration, together with mechanical and physical properties which may militate against safety and the most satisfactory use of the material. On the other hand, neither price nor probable construction cost should be counted as prohibitive factors at this stage of the investigation.

After the list has been completed, any of the standard methods of laboratory testing may be used further to weed out those that should be eliminated. The object here is not so much to determine the actual corrosion rate as to check up on the deductions that have been made from available data, from experience and from opinion. Often these

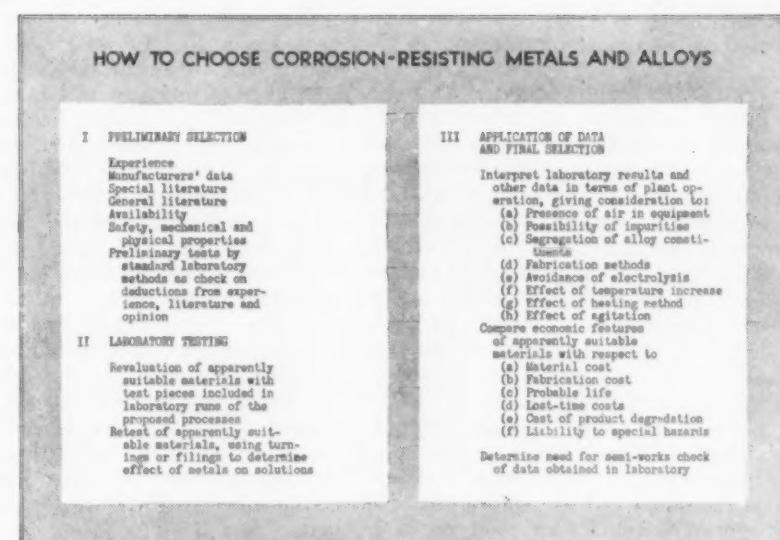
# CONSTRUCTION

tests will show such high corrosion rates that certain of the proposed substances may be eliminated immediately. It is evident, of course, that elimination at this or any other stage is positive, whereas apparently satisfactory performance serves only to put the materials in suspense until one has finally emerged as the best of the lot.

For most purposes of routine testing, ordinary, unaccelerated, total-immersion tests are preferable to the more complicated testing methods. Corrosion test pieces should be reasonably smooth and free from surface oxide and tool marks, although polishing is neither necessary nor desirable. In the conduct of tests, a number of principles should be observed. For one thing, it is important that the temperatures in all tests be the same if the results are to be comparable. Because initial corrosion rates often differ widely from the steady rates that are later established (because of surface effects such as overvoltage, surface inclusions and the formation of protective films), it is desirable to disregard the loss during the first 48 hours of the test, removing the corrosion products formed in the period and averaging the rate obtained in the second 48 hours. It is also apparent that samples of different metals should never be included in the same test, especially when electrolysis might result from their electrical contact. Even metals not in electrical contact may interfere with each other because of the presence of their various salts in solution.

## Tests With Process Fluids

After the preliminary laboratory tests, the next step is to make successive runs of the proposed reaction, including in each test a sample of a possible material. These runs can generally be handled in glass. The object here is to use solutions identical with those that are to be encountered in the actual plant process. Synthetic solutions made from chemically pure ingredients cannot be tolerated. The testing principles noted above should again be followed, and it is advisable to carry temperatures somewhat higher than will be met in the plant in order to be on the safe side. On the other hand, there is no attempt at this stage to duplicate the agitation



that will be used in the plant apparatus, nor to produce a comparable degree of aeration of the reaction solutions. The rates determined, therefore, will be those for the actual process solutions, under more severe temperature, but uncomplicated by the removal of possible protective films, by the effect of air in the equipment, or by electrolytic corrosion that may be met in the final equipment.

This test gives comparative rates of corrosion, but even these rates cannot be used without interpretation in determining the probable life of the equipment. In general, corrosion in the final plant may be from 50 per cent less to 100 per cent more, a considerable spread until it is recalled that the factor of safety of the mechanical engineer is of the magnitude of eight! Thus an indicated life of 15 years may actually turn out to be anywhere from  $7\frac{1}{2}$  to 20 years but it is an encouraging fact that the metal thickness required for purely mechanical reasons will usually provide amply for corrosion.

A word at this point is desirable in regard to the measurement of corrosion loss. Depending on conditions and the material, corrosion may be remarkably uniform across the sample, or it may be characterized by pitting. The actual loss in a pitted sample may be slight, and yet, one pit that goes to sufficient depth will be enough to eliminate the material. Hence, it is good practice to grind down pitted samples until the

pits just disappear, reporting the total reduction in weight as equivalent corrosion loss in inches penetration per year.

Laboratory tests of this sort, properly interpreted, will give reliable indications of the effect of the solutions on the metals, but they require too much time, because of the small surface of metal exposed, to give a true picture of the effect of the metals on the solutions. On this account, the next step, where there is any possibility of contamination of the product, is to repeat the test with turnings or filings of the metals that have so far passed the tests.

When these tests have been completed, the choice can usually be narrowed to two or three materials or less, and it becomes necessary to arrive at a final selection. As has already been stressed, laboratory tests are only as good as the interpretation that is given them, primarily the reason for the disrepute in which they are commonly held. Their extension to the plant requires all the skill that the engineer can apply, but it is noteworthy that with sufficient interpretative experience, he is often safe in using these corrosion rates in the design of final plant equipment, without recourse to the semi-works. Whether he will decide to risk his judgment, or whether he will test semi-works equipment before building the plant will depend on a number of conditions, such as the relative cost of semi-works and plant equipment; the need for semi-works for

purposes other than a final check on his choice of materials (which is often the case); and the possibility that the crucial piece of equipment can be built at small cost from the material selected, while the remainder of the process is carried out in ordinary laboratory apparatus. In the case of very expensive equipment where an error in judgment might mean the loss of a great deal of money, it is obvious that semi-plant equipment is almost imperative.

#### Interpreting Corrosion Data

Interpretation of the laboratory results, in any event, will be the next and often the last stage in the process of elimination. This involves, first, the extrapolation of available data to the proposed operating conditions, and secondly, due consideration of the physical and economic characteristics of the surviving materials. Because the presence of air is a special condition, encountered in some operations, absent in others, it was disregarded in the earlier stages. It cannot be so disregarded at this stage. Copper, for example, shows excellent resistance to acetic acid and good resistance to hydrochloric acid out of contact with the air, and yet it is rapidly corroded when air is present. Hence, although a laboratory test may indicate suitability, plant operating conditions often preclude its use.

At this point it is also desirable to check back to make certain that the test solutions were actually those to be encountered. It cannot be emphasized too strongly that the presence of even small traces of impurities, either in the construction materials or in the process fluids, may completely alter corrosion rates. Arsenic in sulphuric acid, for example, exerts an inhibiting action, while  $\text{SO}_2$  dissolved in the acid increases its corrosion of most materials. The presence of as little as 0.01 per cent of certain organic compounds will decrease the corrosive action of sulphuric acid on iron by 99.5 per cent, while at the other extreme, the existence of only 0.05 per cent of bismuth in lead may increase its susceptibility to sulphuric acid by as much as 1,000 per cent.

Then there is another sort of difficulty that calls for consideration. Alloys of the solid-solution type generally behave toward corrosive agents as if they were chemical individuals, whereas the non-homogeneous, mixed-crystal types generally have the resistance of their poorest constituent, made still poorer by the presence of numerous electrolytic cells. One must, therefore, consider whether alloys of the second sort may not be obtained inadvertently. Certain of the stainless alloys illustrate the possibility. Properly heat treated, they are solid solutions and present their maximum resistance. Improperly heat treated, they

become heterogeneous and subject to intergranular corrosion. In the earlier days of these alloys, high polishing of the finished equipment had to be used to avoid severe attack. Today it is understood that proper heat treatment of the finished equipment will avoid dependence on the extremely thin surface film induced by polishing. As a general proposition, materials that require polishing to bring about corrosion resistance are of doubtful value. If possible, they should always be avoided, as should thin films of any sort which may easily be damaged by operating inadvertencies.

Fabrication methods and mechanical properties now enter the evaluation. Materials that are difficult to fabricate will naturally increase the cost of finished equipment and should be avoided if possible. On the other hand, in any economic comparison of a number of materials it is necessary to consider not only the finished cost of equipment, but also the probable life, the cost of replacement and the somewhat intangible values of lost time due to replacement, degradation of the product through contamination, and the extent to which equipment constructed of the competing materials will be foolproof. A material that is satisfactory when properly handled, but which may easily be ruined by careless operation, is likely to cost a great deal more in the long run than a less fragile or critical material of greater original cost.

#### Avoiding Troubles With Joints

How the joints are to be made in the finished equipment is another question requiring a satisfactory answer. Rivets, unannealed, frequently give rise to electrolysis, as do improper welding and the failure to relieve strains set up by fabrication or cold working. Poor welds may result from oxide inclusions, from the use of improper filler metal, from the segregation of alloy constituents and from cooling strains. Even the threading of pipe may introduce strains that will accelerate corrosion unless annealing follows. Then again, electrolysis will result from the use of different metals in electrical contact when the solution is an electrolyte. Such use of metals of different potential is no safer in equipment than it is in laboratory testing. It must not be overlooked that the mass of chemical equipment is great and that small differences in potential can set up very large currents and produce rapid destruction of the equipment.

The remedy for such difficulties sometimes lies in the choice of materials, but more often in proper fabrication and stress-relieving. In determining whether certain metals can be welded satisfactorily, a simple test is to subject an apparently good sample coupon to a strong pickle of nitric acid or aqua regia until

about half the thickness of the parent metal has been eaten away. If the thickness varies considerably at any point across the sample it is evidence that something is wrong; and until a coupon can be produced that will show substantially uniform corrosion, there is very little point in putting such welding into a piece of finished work. If satisfactory welds cannot be produced, then it is necessary to find a different material or design the equipment so that joints will be above the liquid-level line. This latter method is also useful in avoiding electrolysis induced by rivets.

#### Predicting Effect of Heating Method

Effect of temperature higher than that under which the tests were made is another point that must not be neglected since it almost invariably follows that corrosion rates increase two to three times for each 10-degree temperature rise. It should be borne in mind that the temperature of the corrosive film of liquid in contact with the vessel wall may be several degrees hotter than that of the body of liquid when heat is supplied from the outside; how much hotter will hinge on the methods of agitation and heating. Direct combustion will give results quite different from those obtained with steam, which again are unrelated to those with oil, hot water, mercury, diphenyl or electricity. When there is any doubt of the effect of a particular method of heating, it should be used in check corrosion tests with small-scale apparatus. The possibility that local over-heating will cause the accumulation of corrosion products and the development of concentration cells must also be taken into account.

What effect the agitation of plant equipment will have on corrosion rate cannot be determined with any degree of certainty in the laboratory. Consequently, when there is reason to suspect the formation of a protective film, it is always well to overagitate. A small autoclave of the metal under test, rotated on trunnions and scrubbed internally during its rotation by a handful of quartz pebbles, insures sufficient severity in a case of this sort.

The foregoing has drawn attention to some of the more important principles which the engineer must keep before him. Having done this, he should be in a position to make a final choice. One further warning is to be noted in the application of the material chosen. Although products of different manufacturers may bear the same designation and have ostensibly the same composition, it cannot be assumed that their corrosion performances will be identical. Tests should be considered to apply only to identical products of the same manufacturer, produced by the same methods and given the same heat treatment.

WHEN a new corrosion-resistant material is introduced, it is usually followed, sooner or later, by corrosion tables which purport to show how well the material stands up, usually in comparison with ordinary materials under similar conditions. But it is seldom that an economic comparison of the two materials is offered; and this is just the comparison that must be made if there is to be any logic in the choice of one apparently suitable material over another. Surprising as it may seem, this economic approach is often ignored or, at least, considered so briefly that its results are misleading or valueless. The only way one can be reasonably certain what material will be the cheapest in the long run is to carry an economic analysis to its final conclusion, without permitting guesses or the uncertain evidence of first costs to becloud the issue.

There are a number of different methods of arriving at what may be called "the operating cost of corrosion," some of which attempt a complete evaluation, while others are too inconclusive to be worth much. For example, a comparison may be made by determining the reasonable life of the several materials and dividing the figures so obtained into the cost of each material, thus arriving at the operating cost of corrosion per unit of time. Unfortunately, the method ignores variations in fabrication costs; and more important, the fact that less resistant materials will require more frequent replacement, thus multiplying their fabrication costs.

Consequently, the approach proposed here is to determine how much can be charged directly to corrosion over a period of time when each of several different construction materials is used. First, it should be recognized that the cost of equipment as such is a charge on operation, but not against corrosion. If it can be assumed for the moment that corrosion can be banned at will, it is apparent that the equipment used will be made of the cheapest material that is mechanically suitable. But let corrosion enter the picture and the immediate consequence is an increase in the cost of the equipment, either through the use of more resistant and more expensive materials, or through repeated replacement of the equipment as rapidly as it wears out. Hence, equipment cost can be considered as made up of two parts: the cost of the "bogey" equipment which would satisfy the requirements of a corrosionless process, plus the additions to this cost that are occasioned by corrosion. The latter value is the operating cost of corrosion and is rather a tax on production than a cost of production. How best to reduce the tax is the problem the engineer

## Dollars and Cents— "THE OPERATING COST OF CORROSION"

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Everybody seems to recognize the need for a means of comparing materials of construction on an economic basis, but nobody, so far as we know, has made a previous attempt to work out a method from the fundamentals of corrosion cost. The philosophy expressed here may not be acceptable to every engineer but it makes a start in this important direction.

faces when he endeavors to choose between materials of construction.

But taxes have an unpleasant habit of becoming collectible each year, and so it may be with the operating cost of corrosion. Our hypothetical bogey equipment can be paid for at the start and then written off over a period of years, but the corrosion tax may become payable in full every few years, necessitating replacement of the equipment. Hence, in comparing different materials, it is necessary to assume a period of years during which the equipment will be kept in operation so that the full effect of each visit of the corrosion tax-collector may be considered with each material. What the period should be will logically be determined by the probable useful life of the process, as carried out in equipment of the type under consideration. When obsolescence will set in cannot be foretold, but a period of ten years should usually be a safe one for purposes of comparison. The period chosen is also the one over which the bogey equipment would normally be retired. Then, it is necessary to calculate what the cost of the bogey equipment would be, in place. In addition to the delivered cost of the equipment, "in place" includes the cost of installation.

Having reached this point in the argument, we find ourselves at the most

ticklish juncture of the entire proceeding: determination of the reasonable life expectancy of each material. It has often been maintained that laboratory corrosion data have no place in accurate calculations and that they should never be used in arriving at the life of equipment. As it applies to ordinary published corrosion data, the warning is sound for almost never does the user know the exact conditions under which the tests were run. But experience has shown that properly conducted and properly interpreted laboratory tests, made with the actual plant solutions, can be used as the basis of reasonably accurate life estimates. In fact, in the author's opinion, they are the only recourse aside from the obvious and expensive method of building and operating the plant to determine its life; or the frequently infeasible method of placing samples in reaction vessels at present engaged in the operations for which materials are sought.

[The article preceding this dwells at some length on the performance and interpretation of laboratory tests.—Editor.]

Assuming, then, that the tests have been run, the results interpreted and the unsuitable materials eliminated (including those which would unduly contaminate the product), the next step is to calculate the probable life for each

remaining material, not necessarily for the same thickness for each, but rather for the various thicknesses which, for mechanical (or corrosion) reasons, would probably be chosen in actual practice. There is considerable question as to what penetration should be taken as ending the useful life of any material. In pressure apparatus it is obvious that corrosion must not be permitted to reach the mechanical danger point. In non-pressure equipment, perhaps a loss of one-half the original thickness is as good a criterion as any. With materials that are known to pit under the conditions of operation, it is probably best to consider the depth of the deepest pit as the penetration, despite the fact that the actual weight of material removed may be negligible.

In any event, the corrosion loss, suitably modified to correspond with the changes probably to be met in plant practice, can then be applied to the design thickness of material and the useful life determined, whereupon, to apply the data in comparison, it is only necessary to secure figures for the installed cost of each sort of equipment and the cost of removing each piece that must be replaced.

In arriving at the cost of equipment in place, the items to be considered include the unit cost and quantity of material required, the fabrication and shipment costs, pattern charges in the case of castings (which, for simplicity, are charged only against the first casting if a series is required), and the cost of handling, rigging and installation at the plant. In the case of replacements, an estimate of the cost of removal and salvage must also be determined, together with the probable salvage or scrap value to be credited to the material. In this connection it is to be noted that while certain of the costs will often be nearly the same for materials of similar mechanical and physical properties—fabrication, shipment and

installation, for instance—these similar costs do not cancel out. Every cost of the equipment which in practice would be absorbed by production must be retained and included in the comparative figures.

There are still other costs which might logically be included if it were possible to evaluate them properly. Such costs are: lost time due to failure and replacement; degradation of the product and consequent lowering of the value as a result of contamination; and maintenance over and above the maintenance of the bogey equipment. Perhaps interest should be charged on the materials investment, but this is not recommended because interest is not usually considered a cost of operation.

Then, there are still other features of the competing materials which cannot possibly be given a dollars-and-cents value. Such are fragility, safety, and prestige value, prejudice and partiality to certain manufacturers or materials. Although they cannot be evaluated, some or all of these will find their way into the choice, if not into the calculations.

By this time it will have become evident that the operating cost of corrosion can be made a very imposing, if not a very reliable, figure. The more one attempts to include, the more imposing it becomes—and the more likely to mislead. After all, the figure arises from estimates and depends on corrosion rates which at best are somewhat speculative. Therefore, it seems preferable to limit it to the more important conditions that beset it, reserving the franker of the "guesstimates" for final decisions between close competitors. In the exemplification of the method now to be made, only those factors will be used that have been discussed in detail above.

According to the foregoing, a ten-year period is generally suitable for the comparison. If the expected useful life of any material is  $L$ , then the number

of replacements will be  $10/L$ , which, of course, must be expressed as the next higher whole number. The total cost of any piece of equipment in place, the first time it is installed, will be the sum of the costs of material, fabrication, shipment to the plant and installation. In the case of replacements, there will be an additional charge for removal and salvage which is credited with any salvage or scrap value. At the end of the period, a removal and salvage charge must be made if advantage is to be taken of the salvage value. Furthermore, from the sum of the costs of the original and replacement installations, it is necessary to deduct the cost of the bogey equipment in order to reduce the figure to the operating cost of corrosion. Expressed mathematically, the relation is as follows:

$$O.C.C. = \frac{10}{L}(M + F + Sh + I + R - S) - B$$

where  $L$  is the expected life in years,  $M$  is the total cost of material,  $F$  is the fabrication cost,  $Sh$  is the shipping cost,  $I$  is the installation cost,  $R$  is the cost of removal and salvage,  $S$  is the salvage or scrap value, and  $B$  is the cost of the hypothetical piece of bogey equipment.

For the sake of illustration, an example has been calculated for three purely imaginary alloys,  $X$ ,  $Y$  and  $Z$ , which have been selected for comparison under a set of assumed conditions applying to the manufacture of a 100-gal. kettle to be supplied without jacket or agitator but to include a cover. Design data and ensuing calculations form the basis of Table I, while material from Table I, together with estimates from experience and quotations of fabricators and railroads are used in deriving Table II. The latter, it is to be noted, is simply a listing of the items of the equation. Using the data in the indicated manner we arrive at the results of the last column which show, for the conditions of the problem, that the most expensive material is actually cheapest.

Table I—Design Data for Corrosion Cost Calculations

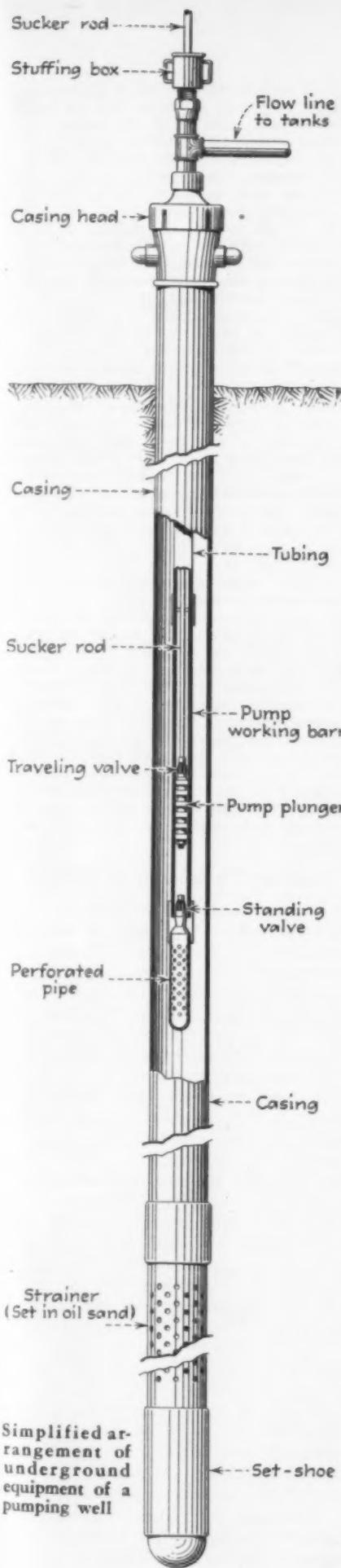
Material	Form Used	Design Thickness, Inches	Permissible Penetration, Inches	Corrosion Rate, Inches per Year	Probable Life, Years	Density, Lb. per Cu.In.	Total Volume of Material, Cu.In.	Total Weight of Material, Pounds	Unit Cost of Material, Dollars per Pound
Bogey	Plate	1	1	0.5	0.5	0.28	3,250	910	0.02
X	Cast	1	1	0.05	5.0	0.25	5,200	1,300	0.05*
Y	Plate	1	1	0.09	4.2	0.28	2,600	730	0.30
Z	Plate	1	1			0.32	3,900	1,250	0.15

\*Cost per pound of finished casting.

Table II—Summary of Elements of Operating Cost of Corrosion

Material	Replacements $10/L$	Material Cost, Dollars, $M$	Fabrication Cost, Dollars, $F$	Shipping Cost, Dollars, $Sh$	Installation Cost, Dollars, $I$	Removal and Salvage Costs, Dollars, $R$	Salvage Value, Dollars $S$	Gross Equipment Cost, Dollars, for 10 Years	Net Cost of Corrosion Dollars O.C.C.
Bogey	20	19	100	9	20	12	..	148	980
X	2	52	100*	13	25	10	30	754	606
Y	3	220	150	7	20	12	30	804	656
Z	3	188	150	12	25				

\* Pattern charge for first unit only.



# PETROLEUM PAYS INCREASING TOLL TO CORROSION

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**D**ESTRUCTURE of equipment by corrosion is an important problem in practically every branch of the petroleum industry. From the bottoms of the wells which produce the crude oil to the final steps in transportation and storage of the finished products, metal equipment is exposed to corrosive attack. The petroleum industry in the United States produces and processes daily 2,000,000 barrels of oil, and an even greater quantity of salt water. All of the steps involved in handling this great volume of more or less corrosive fluids are attended by corrosion troubles. Although much study has been given to the solution of these problems, and although a great deal of progress has been made, the trend of development of the oil industry has been such as to occasion a steady increase in the losses arising from corrosion of equipment. The fact that these losses have increased, despite the progress which has been made in their solution, is attributable to the development of large production of oils of high sulphur content, and to the use of higher temperatures and pressures in refining operations.

The corrosion problems which are encountered in producing, transporting and refining petroleum are extremely diverse. Differences in temperature, pressure and composition of the fluids handled result in great variations in the nature and severity of corrosion experience, and in a correspondingly great variation in the methods of corrosion prevention which must be used. Although no strict classification is possible, a rough division of corrosion problems of the oil industry may be based upon the nature of corrosive agents, and upon

the physical conditions which affect corrosive action. An abbreviated list of the more destructive corrosive conditions follows:

- a. *Oxygen free oil-well brines.*  
Salt brines containing up to 25 per cent dissolved solids are produced with the oil. Sodium chloride is the predominant constituent, but calcium and magnesium chlorides, sulphates and bicarbonates are present. In many fields, the brines also carry sulphides.
- b. *Aerated oil-well brines.*
- c. *Hydrogen sulphide, air and water.*  
In vapor spaces above the oil in tanks handling sulphide-bearing oils.
- d. *Corrosion by soils.*
- e. *Corrosion in low temperature distillation.*

Corrosion experienced on sections of distillation equipment on which water may be condensed. Hydrochloric acid is formed by hydrolysis of calcium and magnesium chlorides from the salt water which is contained in almost all crude oils. When hydrogen sulphide is present, this corrosion is greatly accelerated.

- f. *Corrosion in high temperature distillation.*

Equipment for cracking and distillation at temperatures above 400 deg. F. is subject to rapid corrosion. Sulphur and sulphur compounds are the active agents in this corrosion, which is believed to proceed by direct combination of sulphur and metal.

In a sense, the corrosion of underground equipment of wells is the most serious corrosion problem of the industry, because of the magnitude of the indirect losses which it occasions. Corrosion of surface equipment, such as tanks, pipe lines and refinery equipment, causes great loss of material and considerable interruption of operation, but

can usually be handled in such a manner as to minimize losses other than those of material. Corrosion of well equipment, on the other hand, makes necessary large expenditures for labor and repairs, and results in losses of production of oil far greater than the direct costs of corroded material and repair labor. In many cases, corrosion of underground equipment has resulted in irreparable damage to the oil-bearing formations, and has made unrecoverable, by any economical means of production, large quantities of oil which would otherwise have been produced. Evaluation of these indirect losses is exceedingly difficult; and their importance is not fully recognized even within the oil industry. Direct losses in labor and material caused by corrosion of well equipment in the United States average more than one cent for each barrel of oil produced; although no estimate of the magnitude of the indirect losses is possible, they are known to amount to more than five cents per barrel of oil produced in certain territories.

*Oil-well strainers.* In the salt-dome oil-fields of the Texas and Louisiana Gulf Coast, the nature of the oil-bearing sands is such that strainers or screens having mesh openings from 0.008 in. to 0.016 in. must be used to exclude the sand from the wells. These strainers are made upon pipe, either by spaced wrappings of wire, or by the insertion of slotted buttons. They are subject to corrosion by well fluids, and their failure occasions very great indirect losses. Strainer failure is the most usual reason for the abandonment of wells in the Gulf Coast; although repairs are possible, and are commonly made, the repaired well is seldom as productive as was the well before the failure. The only practical method of combating strainer corrosion is by the use of metals and alloys which resist the action of the well fluids. Due to the magnitude of the indirect losses, expensive materials can be used. Brass and bronze are satisfactory in the absence of hydrogen sulphide, but are coated with corrosion products, which clog the screen mesh, when sulphide is present. Stainless steels are unsatisfactory when sulphide is present. Commercially pure nickel has been found to be more resistant to corrosion by well fluids than any other economically usable metal, and has been used for the fabrication of well strainers to meet exceptionally severe conditions.

*Oil-well casings.* The walls of an oil-well are formed by the casing, which is heavy pipe of large diameter, used to exclude formation water and gas, and to support the walls of the hole. It is corroded both by the fluids produced from the well, and by corrosive waters in unproductive formations penetrated in drilling. Failure of casing may admit water to the well and flood the oil-bearing sands. Expensive alloys cannot be used for casings, due to the large quantity of pipe which is needed for the purpose. With steel casing, the investment ranges from \$5,000 to \$25,000 per well, depending upon the depth and territory, and the cost of alloyed materials would be excessive. Wrought iron, copper-bearing steel and galvanized casing protected by the use of non-metallic coatings



Corroded oil-well strainers from wells of the Texas Gulf Coast. Above: Wire wrapped strainer; Below: Button-type strainer

have not been successful. Good results have been obtained, however, by protecting the outside of the casing with cement or alkaline mud fluids, pumped into place after the casing has been set.

*Oil-well tubing.* The tubing is a flow-string which is carried within the casing, and through it the fluid flows or is pumped to the surface. In some areas the tubing is rapidly corroded. Economic considerations limit the selection of tubing materials to inexpensive ferrous metals and alloys; low carbon steel is the most generally used material, although wrought iron tubing is extensively employed. Copper-bearing steel, containing as much as 1 per cent Cu., has given very satisfactory service in some fields, while galvanized steel and wrought iron tubing are commonly used in areas where tubing corrosion is exceptionally severe. Chemical neutralization of well fluids fed in between the tubing and casing has proved successful and economical in a few fields, but the costs are excessive in most areas.

*Oil-well pumps.* Fluid is pumped from the oil wells by a simple type of reciprocating pump carried on the bottom of the tubing string and actuated by a string of rods reaching to the surface, inside of the tubing. The simplest type of pump, and the most commonly used, consists of a working barrel secured on the bottom end of the tubing, a standing valve and a piston built up of flexible cups which carries the traveling valve and which is attached to the sucker rods. Corrosion of working barrels and of valve balls and seats occasions considerable losses, particularly in repair costs and in loss of production during shut downs. Special alloys, particularly chromium and chromium-nickel stainless steels, are very generally used for valve balls and seats. Working barrels of brass and other alloys have been widely used, and experiments are now being made with liners about  $\frac{1}{8}$  in. thick, which are made of brass, bronze, chromium-nickel steels, or nickel, for use inside the steel working barrels. Chromium plating has also been successfully employed on working barrels and other types of well pumps.

*Sucker rods.* Corrosion of the sucker rods which actuate well pumps is probably the most generally prevalent of all well corrosion troubles. Its results are manifested more in mechanical breakage of rods than in wasting of rod metal. Sucker rods are subject to alternating stresses of considerable magnitude, and corrosion fatigue failure is the most common cause of breakage. Special alloyed steels of high tensile strength are used for the manufacture of sucker rods. Wrought iron sucker rods have proved successful in resisting corrosion fatigue failure, and galvanized rods have been used in some areas.

#### Surface Equipment in Oilfields

From the wells the fluid flows to tanks in which the water is separated from the oil. When corrosive fluids are produced, the flow lines are subject to internal corrosion. This is seldom a serious problem, as the lines are usually laid on the surface, and are easily repaired. The tanks to which the fluids flow are subject to severe corrosion both by salt water, and in sulphide areas, by the gas above the oil. These tanks are usually of bolted construction, ranging in capacity from 100 to 2,000 barrels, and are made of steel plates from 14 to 10 gage in thickness. In some areas, tank bottoms are punctured by corrosion in from three to six months, while the roofs in some of the sulphide fields have a life of less than 18 months. The bottoms are repaired and protected by laying slabs of concrete, or by coatings of asphalt or coal-tar pitch. Repair of the roofs is far more difficult and expensive. Coatings of all types have been used in an attempt to reduce corrosion of the roofs by hydrogen sulphide, air and water, but no coating of the paint, lacquer, varnish or resin type has given satisfactory service.

Aluminum foil, cemented to the under sides of the roof with special Bakelite varnish, has given satisfactory protec-

tion, and excellent results have been reported from the use of a sprayed coating of special aluminum stearate grease. Tank roofs of aluminum plate are highly resistant to corrosion, but are prohibitively expensive. Excellent results are being obtained on test installations of tank roofs with galvanized wrought iron or ingot iron plates, and these appear to present the most practical and economical solution of the problem. Wooden tanks are widely used in fields where corrosion is severe, and are highly satisfactory from the corrosion standpoint. They do not, however, possess the advantages of portability and gas tightness.

Disposal of the salt water, after it has been separated from the oil, is attended by extremely serious corrosion difficulties, particularly where it must be pumped through pipe lines. Cast iron lines are most generally used for the purpose, but are not entirely satisfactory, since they corrode somewhat readily, and their capacity is greatly reduced by the accumulation of corrosion products. Steel pipe, lined with bituminous coatings, has been used without great success, although satisfactory methods of selection and application of such bituminous materials may be developed in the future. Cement-lined pipe is satisfactory for this service, and wood-stave pipe may be used with absolute freedom from deterioration where the pressures are not too high.

From the production tanks, oil is gathered through pipe lines into large storage tanks at pipe-line stations, from which it is pumped into the trunk pipe lines. Soil corrosion of these trunk pipe lines causes a greater loss of material than does any other corrosion problem of the oil industry. It has been recently estimated that corrosion of pipe lines in the United States causes an annual loss of \$143,000,000 in pipe material. Approximately 40 per cent of this total loss is caused by corrosion of oil pipe lines.<sup>1</sup>

### Corrosion of Refinery Equipment

From the pipe lines, crude oil is delivered to the refineries. The refining of oil is attended by an almost bewildering variety of serious corrosion troubles. The major loss entailed by corrosion of refinery equipment is loss of material. By a proper schedule of operation it is possible to replace most corroded material during cleaning of equipment, and thus avoid unnecessary interruption of production. This is not always true, and corrosion of some of the modern high pressure cracking equipment may make necessary very costly shutdowns.

<sup>1</sup>EDITOR'S NOTE. Refer to Mr. Gill's discussion of pipe-line corrosion in *Chem. & Met.* July, 1932, pp. 399-403.

The following very brief discussion is based upon a rough classification of refinery corrosion according to the nature of the corrosion reactions:

*Low temperature distillation equipment.* Equipment used for the fractionation of crude oils is corroded, primarily, at points where water may exist in the liquid state. Hydrochloric acid is formed in the distillation of almost all crude oils, since these usually contain from 0.5 per cent to 2 per cent water, in which calcium and magnesium chlorides are dissolved. Dissolved oxygen and carbon dioxide accelerate this corrosion, which is also affected by naphthenic acids from the crude oil. Where hydrogen sulphide is present, fractionation equipment is subject to exceptionally severe corrosion. Portions of fractionating equipment which are at temperatures above 400 deg. F. are directly attacked by hydrogen sulphide. This type of corrosion will be discussed in connection with the corrosion of pressure stills.

Low temperature corrosion affects pre-heating equipment used ahead of the stills, the tubes, return bends and plugs of pipe stills, or the shells of shell stills, the bodies, trays and caps of fractionating towers, run-down lines, condensers and rundown tanks. Chemical neutralization is almost universally employed for the mitigation of low temperature corrosion of refinery equipment. Ammonia, caustic soda, soda ash and lime have all been successfully employed for the purpose. Special metals, particularly Admiralty metal, special bronzes, chromium nickel, stainless steels and pure nickel are used for heat exchangers and condensers, and for return bends and plugs in pipe stills. No paint or sprayed coating has been successful for the protection of surfaces corroded by hydrochloric acid.

*Pressure Stills.* The most serious corrosion problem in refining operation is that which is caused by high-temperature corrosion of pressure still equipment. This corrosion is not appreciable at temperatures below 400 deg. F., and becomes rapid at temperatures above 700 deg. F. It is directly influenced by the sulphur content of the oils handled, and is not serious when the sulphur content is below 0.3 per cent. With higher sulphur content, rates of penetration as high as one inch per year have

been reported in the hotter parts of the high pressure equipment. Studies of the mechanism of this corrosion indicate that it is probably in the nature of a direct combination of sulphur and iron.

The corrosion affects all parts of the high pressure equipment, being most severe where the temperature is highest. The tubes and return bends of the heating elements are rapidly attacked. Alloyed tubes are extensively employed; 18-8 chromium nickel steel tubes give good service, but the cost is high. The present trend is to the use of 4 per cent to 6 per cent chromium steel tubes for the first stages of the heating, and of 18-8 for the tubes which are at the highest temperatures. Some difficulties are experienced with these alloy steels, and carbon steel tubes are still extensively employed. No types of lined or plated tubes have as yet been found to give service equal to that of alloy steels.

The heavy reaction chambers or soaking drums are subject to severe corrosion, penetration rates of more than 0.2 in. per year having been experienced. Linings of concrete, fire clay and ganister give reasonably satisfactory protection for these chambers. Chromium plating has been quite extensively employed, and one manufacturer of pressure equipment is now prepared to furnish steel chambers lined with resistant steel.

Evaporator towers and fractionating towers are badly corroded when high sulphur oil is handled, but cast iron and steel are commonly used for their fabrication because of the rapid obsolescence of cracking equipment. Steel transfer and rundown lines have been replaced in many instances with low carbon 18-8 chromium-nickel steel. Condensers and coolers used with pressure stills are corroded in the same manner as in the case of low-pressure distillation equipment.

It is common practice, in pressure still equipment, to use a greater thickness of metal than is required to meet pressure conditions, in order to take care of possible corrosion. Recent practice involves the drilling of small holes into the walls of the equipment to such a depth that leakage through them will indicate corrosion before it has dangerously weakened the walls.

Chemical neutralization has been employed to reduce high-temperature sulphur corrosion, with fair success. Ammonia is worthless for the purpose, but caustic soda, soda ash and lime may be used.

Many other corrosion problems are encountered in refinery operation. This is particularly true of equipment for handling acid and for the acid treatment of distillates, where large quantities of acid-resistant alloy equipment are used. Much corrosion is also experienced with water used for cooling purposes.

In so brief a survey it has not been possible to enter into any detailed discussion of the costs, nature or methods of prevention of the corrosion problems of the oil industry, nor has it been possible to refer to the numerous excellent papers dealing with these problems. An attempt has been made to indicate the diversity and the economic importance of corrosion problems to the oil industry, and to show that further study is needed before final remedies can be prescribed.



Corroded oil-well casing

# PULP AND PAPER

## ADVANCE IN FIGHT AGAINST CORROSION LOSS

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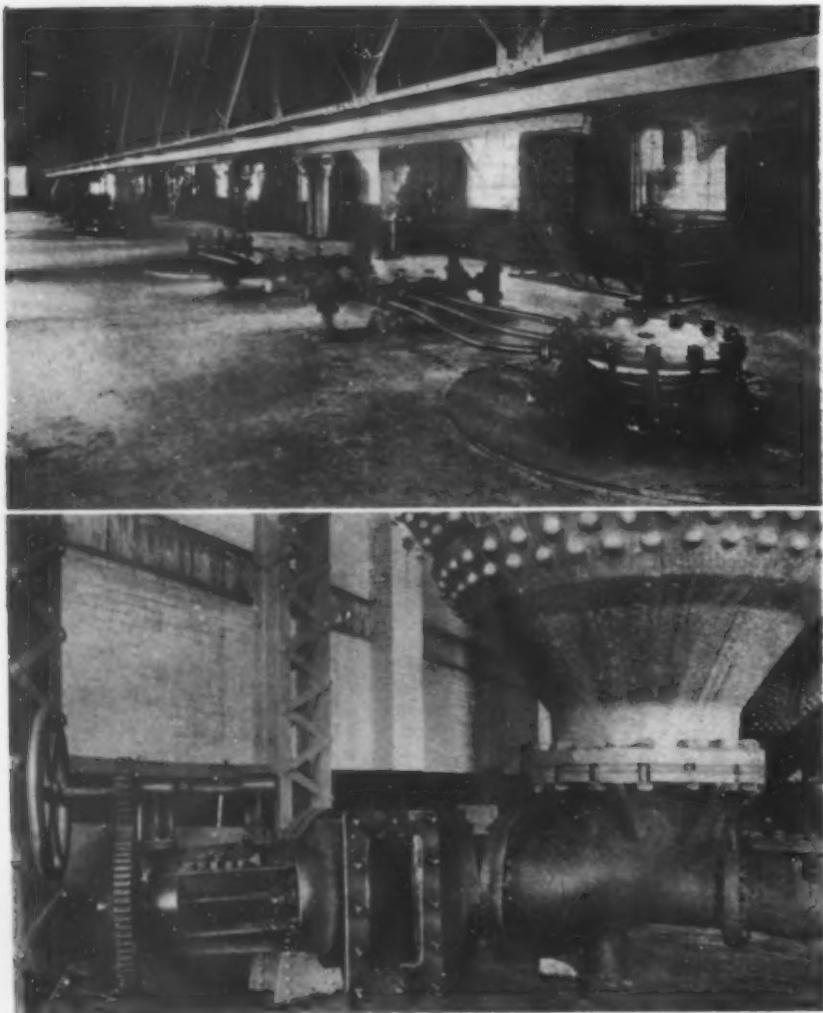


Fig. 1—Digesters in the plant of the Restigouche Co., Ltd., top and bottom views of which appear above, have operated satisfactorily with complete chrome-nickel-steel equipment since 1929

**P**ULP AND PAPER technology presents a variety of service requirements for process equipment materials, some of which are peculiar to the industry while others are common in many industries. The latter class are referred to below only when warranted by special conditions of this industry. The former class may best be presented by a short outline of the unit operations involved and of the chemical and mechanical action to which the materials are exposed.

Wood is the main raw material of paper manufacture, with spruce, hemlock and balsam pulped by the sulphite or acid process and the hard woods and pines by an alkaline process. After it arrives at the mill, the wood is cut into bolts 4 to 8 ft. in length, the bark is removed mechanically, and the bolts are reduced to chips of suitable size. Notable economies in these operations have been realized by the application of hard-facing alloys to the cutting and wearing surfaces. Such alloys are also finding favor at other points of severe abrasive wear.

In ground-wood mills, wrought iron, cast iron and steel are used for grinder construction, for although the pH of the water in circulation will range from 3.9 to 5.2, corrosion difficulties are slight. The largest materials item in ground-wood production is the stone against which the wood is held by hydraulic pressure. Sandstone has been the usual material, with artificial stones of superior properties now replacing the natural sandstone to a considerable extent.

### Sulphite Process

Production of the SO<sub>2</sub> for the cooking acid is the first step and involves the use of sulphur burners which are usually of the Glens Falls type of rotary or the more modern spray type. Gas concentrations range from 12 to 20 per cent SO<sub>2</sub>, depending on the burner used and the operation. The combustion chamber is a steel shell lined with silica brick. As gas temperatures at this point are from 600-1,200 deg. C., some maintenance is required, particularly on the outside surface which is usually exposed to the weather.

The burner-gas cooler is usually of the vertical lead-pipe type, wherein the temperature is reduced to a maximum of about 40 deg. C. The gas fan, cooled-gas lines and acid lines are of 10 per cent antimonial lead. Burner-gas lines to the combustion chamber and cooler are of cast iron. Cold-acid valves are commonly lead-lined bronze with water-sealed lead gas valves.

Reaction towers, which are two in number in modern practice, as well as the recovery tower and the cooking acid storage tanks, are now made of concrete lined with acidproof tile. Long-leaf pine tanks are good for from 15 to 20

years. Raschig rings, other tile shapes and oak blocks are used as recovery-tower packing.

A modern sulphite digester producing 20 tons of pulp per cook will be about 15 ft. inside diameter by 50 ft. high, of welded or riveted steel construction and lined ordinarily with acid-resisting silica brick. Recent developments include the use of carbon bricks or thin sheets of suitable chrome-nickel steel welded to the digester shell and to all exposed parts. Digester accessories such as liners for the inside of the digester head, valves, bottom bowls for the digester, strainers, thermometer wells, pumps and pipe fittings have usually been of bronze of various analyses. Piping has been made of extra-heavy brass or copper.

Very promising results have been obtained, particularly when electrolytic action has been avoided, by the use of the chrome-nickel steels for the above castings and pipe. A digester in the mill of the Restigouche Co., Ltd., Campbellton, N. B., top and bottom views of which appear in Fig. 1, was completely equipped with these alloys in 1929 and is today giving complete satisfaction. The range of analyses now being used is indicated below.

	Castings Per Cent	Wrought Meta l Per Cent
Cr	17.50-30	16.5-22
Ni	8.50-12	7.0-11
C	0.07-0.30	0.07-0.20
Si	0.50-1.50	0.75 max.
Mn	0.40-0.80	0.50-1.50 max.
P	0.04 max.	0.03 max.
S	0.05 max.	0.03 max.
Mo	To 4.00*	0-4.00

\* Optional.

Cooking acid contains 5.0-6.5 per cent total SO<sub>2</sub> with a maximum cooking temperature of about 160 deg. C. at 80 lb. per square inch pressure. Heating of the digester is done either by direct or indirect steam. Chrome-nickel steel of suitable analysis permits taking advantage of the latter method. In Fig. 2 are shown top and bottom views of an external acid heater and accessories at The Rhinelander Paper Co., Rhinelander, Wis. Digester relief during cooking consists of about 100 per cent SO<sub>2</sub> saturated with water vapor and carrying some entrained organic matter. Heat-recovery systems provide for returning this hot relief to freshly charged digesters, either directly or from an accumulator.

Regardless of the heat-recovery system, some relief must be cooled and recovered for values. The separator is a steel shell lined with silica brick. Recovered gas and liquor coolers are of various designs from simple lead pipes submerged in water to tubular coolers. Blowtanks in which the pulp is separated from the waste acid are usually of wood with perforated bottoms. Tile shapes are being successfully replaced by chrome-nickel steel

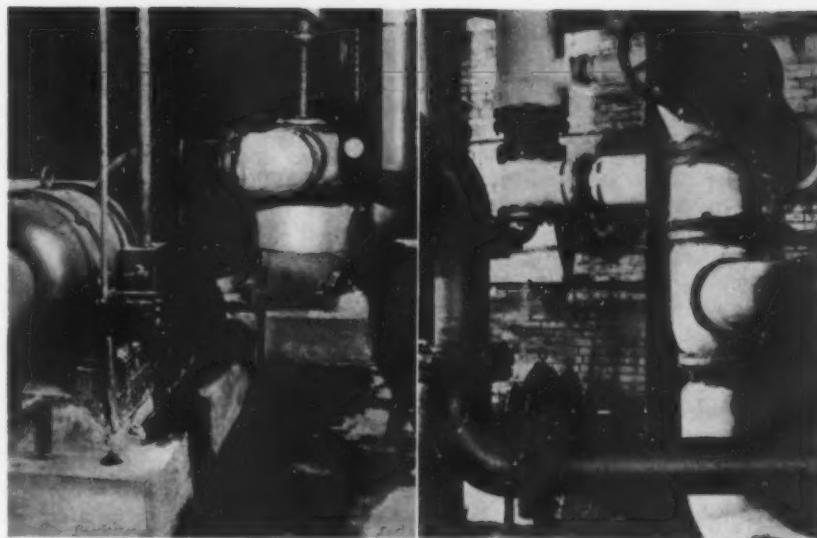


Fig. 2—Circulating pump at the top, and bottom connections of The Rhinelander Paper Co.'s external acid heater which is equipped with chrome-nickel steels

sheets of about 16 ga., with 3/32-in. holes on 1/2-in. centers. The waste acid is about 0.1 N and, when recovered, is generally neutralized and then concentrated in steel evaporators.

#### Alkaline Pulping Processes

With few exceptions, the alkaline pulping processes present relatively mild service requirements in comparison with the sulphite process. In the soda process the wood preparation is similar to that described, with slight variation in chip size. The cooking medium is NaOH of about 12 deg. Bé. at 16 deg. C. Digesters are usually smaller than sulphite digesters, unlined and supplied with heat insulation on the outside. Aside from a slight pitting on the under side of the covers and at the liquor level, no appreciable attack has been observed after years of operation. The shells are now welded and operate at from 80 to 130 lb. pressure.

It is unnecessary here to detail the series of steps following pulping, whereby the pulp is blown into a receiving tank, drained to a series of wash pans equipped with false bottoms to separate the liquor, and finally washed free from liquor. This light liquor is then evaporated in any one of several standard types of evaporators, increasing the concentration to about 40 deg. Bé. for burning. Optionally, the evaporation may be carried to a lower concentration with disk evaporators, utilizing waste heat from the furnaces in completing the concentration.

Recovery of the sodium salts from this black liquor is accomplished by burning the organic matter in rotary or spray-type furnaces of various designs. For good economy, 80-90 per cent recovery should be obtained. Values from the furnace stack are recovered

with a Cottrell, filter or wet scrubber.

In all the operations listed, iron and steel are satisfactory materials for equipment, with the exception of the lining for the furnaces which presents a difficult problem. Soapstone has been largely used, in which case the lining lasts about six months. The best grades of chrome brick increase the life to about a year. Although the application is at present in the developmental stage, the use of unburned magnesite brick has shown possibilities for this service.

The kraft or sulphate pulping process differs from the soda process in its cooking liquor, using a mixture of 40-65 grams per liter of NaOH and 15-40 grams per liter of Na<sub>2</sub>S. A modern kraft digester is usually about 8 ft. in diameter by 25 ft. high, with a capacity of about 4 tons. The various steps in pulp separation and soda recovery are similar to the soda process, except for the addition of Na<sub>2</sub>SO<sub>4</sub> to the black liquor before burning. The final step in the alkaline processes is the leaching of the black-ash from the furnaces, leaving only finely divided carbon, and the causticizing of the sodium salts with lime.

Whatever the pulping process, as it is blown from a digester the pulp must be screened to remove uncooked knots or chips and foreign material. Variously designed flat vibrating or rotary screens are used, with screen plates usually of bronze. Chromium plating of these screens is meeting with success and the advantages of that hard, smooth surface are obvious. Chromium plating is one of the outstanding materials developments in the industry and is being used in suction-box covers, calender rolls and evaporator tubes.

Bleaching of pulp, when required, is

accomplished without serious detriment to construction materials other than to metal sash and building interiors which require protective coatings or paint. The several designs of bleacher in use are lined with tile which is satisfactory. Bleach liquor lines of wrought iron have a life of about a year, and cast nickel-iron lines, about three years. Iron valves and fittings are likewise satisfactory.

Generally pulp, whether bleached or not, is unsuited for paper making and must undergo a process of refining, with the addition of size, color or other materials. The size is usually a rosin soap made by saponifying rosin with soda ash, which presents no materials problem. This size is introduced into the beater where it is dispersed by aluminum sulphate. When the latter is added as a solution, a severe corrosion problem arises, which is usually met by the use of silicon-iron castings of about 15 per cent silicon. This situation is avoided by the use of the alum in dry form.

Two refining units are in common service, the beater and the jordan. Sizing is done in the former which is constructed of wood, concrete or cast iron. Mechanical wear on the bars of the beater roll and bed plate is severe, while the life is still further reduced by the fact that the pH in the beater may be as low as 4.0. Although common

steel and bronze are used for bars, greater life is had from the more expensive chromium or chrome nickel alloys which combine excellent strength with resistance to the reagents present. The same construction materials are used for the bars of the jordan.

Paper manufacture consists in the formation of a sheet from a dilute water suspension of properly refined pulp, using Fourdrinier, Harper Fourdrinier, Yankee and cylinder machines which are different mechanical units for producing the various classes of sheets. A large item in the cost of making paper with the Fourdrinier is the machine wire which, as a fine, endless wire screen of about 65 mesh, travels at from 1,000 to 1,500 ft. per minute. The wires are usually of brass although other ferrous and non-ferrous alloys have also been used.

A detailed enumeration of the materials used in a paper machine would be lengthy. Brass, rubber, wood, granite, aluminum, cast iron and other materials are applied where their properties indicate them to be suitable. It is noteworthy that chromium plating of the heavy cast-iron calender rolls has given increased service life. Unplated, rolls often become so grooved in operation that regrinding is required at intervals of one to four weeks in severe cases.

Since 1.5 to 2.5 tons of water must be evaporated by the dryers per ton of product, machine room construction and ventilation require special attention. To avoid condensation, particularly in northern latitudes, machine hoods and the machine-room roofs are constructed of asbestos, magnesia, cork or similar compositions in the form of slabs or panels. The evaporated water vapor at 50-70 deg. C. is then passed through a suitable heat exchanger, usually of copper, where the heat, in part, is given up to fresh, incoming air and distributed to the dryer and machine room. When sulphite papers are made, the vapor may contain  $H_2SO_4$  resulting from the oxidation of  $SO_2$ . Chlorine and hydrochloric acid may be present, depending on local conditions. With a bronze impeller for the exhaust fan and sheet-iron air ducts protected by asphalt-base paints, the ventilating system presents no severe conditions.

When it is considered that from 6,000 to 50,000 gal. or more of water is used per ton of product, it will be realized that piping is an item of importance. In making fine papers it is essential that contamination from iron or other sources be avoided. For this service wood, wood-lined steel, cement-lined cast iron and copper pipe are used. Otherwise steel and cast iron are standard for water and stock handling.



## DYE INDUSTRY SEARCHES FOR CHEAPER PLANT MATERIALS

NOT MANY years ago the research dye chemist had to develop processes which not necessarily gave the best yields, but which could best be handled in the limited number of construction materials then available. This situation is gradually changing, and new processes are constantly being introduced, effecting large savings because of the availability of new materials for equipment construction. Maintenance and depreciation charges still continue to be large items on the cost sheets, however, and improved processes are awaiting still cheaper materials of construction before they can be introduced on a commercial scale.

Sulphonation or nitration of benzene, naphthalene, and anthracene, or their derivatives, is the starting point of most of the dyes. Cast iron is used for prac-

tically all sulphonations, oleum or concentrated acid being necessary for the majority of the reactions. To obtain maximum service from cast iron when it is used to handle acid reactions, its composition and physical structure must be carefully controlled. The carbon should be present as the carbide or "cementite" with as little free graphite as possible. "Chilled" castings give this structure on the inside of the vessel where it is needed, at the same time retaining the mechanical strength of grey iron. These castings are greatly improved by the addition of up to 25 per cent Mayari iron which contains 1-1½ per cent of nickel and 2-2½ per cent of chromium, with smaller amounts of vanadium, titanium, and cobalt.

Most nitrations are carried out in cast iron, as the nitric acid is either intro-

duced as mixed acid containing 60-70 per cent of sulphuric, or is formed directly in the nitrator by adding sodium nitrate to the excess acid after sulphonation. When the latter method is used the total acidity may become quite low. When 3:6:8 naphthalene trisulphonic acid is nitrated in this way, the sulphuric acid concentration at the start is around 70 per cent. The temperature is kept below 40 deg. C. and at the end of the nitrate addition the acid content is only about 50 per cent. Cast-iron nitrators have been used in this and similar

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service for over ten years with very little wear.

Nitric acid is rarely used in appreciable amounts without the protection of its brother, sulphuric, which permits the use of iron or steel equipment. When nitrating, very efficient agitation is of the utmost importance to prevent the formation of pockets of high nitric content, causing rapid local corrosion.

In the distribution of the usual plant nitric acid of 70 per cent strength, aluminum piping is used, and blow cases or pumps are fabricated from 18-8 chrome-nickel steel. Steel storage tanks of riveted construction and steel valves and pipe fittings are used in distribution of oleum and concentrated  $H_2SO_4$ .

In general, cast iron and steel are quite satisfactory for handling reactions involving sulphuric or mixed acids at any temperature when the ratio of water to acid does not exceed 1:10.

#### Lead Both Cheap and Resistant

Next to iron and steel, lead is the metal most commonly used, and its uses and limitations are well known. It is really only resistant to sulphuric acid in concentrations up to 65 per cent at temperatures not exceeding 40 deg. C., or at higher temperatures when the concentration is kept below about 40 per cent. It is used so widely because of its cheapness and ease of replacement. As ordinarily used its rate of solution is so slow as to preclude the use of more expensive materials, if indeed they should be more suitable. Solutions containing up to 10 per cent hydrochloric acid may be handled in lead when the temperature is kept below 10 deg. C., and concentrations of 5 per cent or less may be handled at slightly higher temperatures. Alpha nitro-naphthalene is made in lead-lined vessels by adding solid sodium nitrate to a mixture of naphthalene and 50 deg. Bé. sulphuric acid at a temperature of 55 deg. C.

With a few exceptions, so far as corrosion resistance is concerned, there is little choice between chemical lead and "hard" or antimonial lead. The latter is preferred because of its greater mechanical strength, and with some acids, particularly sulphurous, it shows much greater resistance than soft lead. Hard lead must never be used for handling food colors or their intermediates, as arsenic is always present with the antimony and even minute traces will cause rejection of the dye.

Aluminum bronze is used for about the same service as lead. It will stand up better than lead at high temperatures and may be used with slightly higher hydrochloric-acid concentrations. Because of its cost it is usually not employed for the bodies of kettles or autoclaves, but finds its greatest use in agitators, shafts, and pumps.

Everdur, a copper-silicon-manganese alloy, is being rapidly introduced for service in that range of sulphuric acid concentrations between 40 and 65 per cent at temperatures exceeding 50-60 deg. C. where lead corrodes too rapidly to warrant its use. For example, in the manufacture of naphthalene beta sulphonate, after sulphonation the alpha sulpho acid is hydrolyzed back to naphthalene at a temperature over 150 deg. and sulphuric acid content of 40 per cent. Lead was tried, but dissolved far more rapidly than laboratory corrosion tests indicated. No more trouble was experienced after the installation of an Everdur hydrolizer.

Reduction of nitro compounds to amines is usually accomplished either by ferrous chloride or acetate in slightly acid solution, or by nascent hydrogen in comparatively strong acid. When the latter method is used the corrosion problem becomes very acute as soon as the amine is salted out. For instance, when amino H-acid is made by this process the nitro body is diluted to about 14 per cent acidity and circulated over sheet scrap at 50 deg. C. until reduction is complete. The acidity drops to about 9 per cent, and up to this point lead is satisfactory. Salt is now added to precipitate the crude amino H-acid, and the sulphuric acid present is strong enough to react with it to a certain extent, forming 2-3 per cent of hydrochloric acid. If air agitation has been used, small quantities of nitric acid are also present. The only metal which stands up satisfactorily in this slurry is Hastelloy C, and where air lifts cannot be used, centrifugal pumps made of this alloy have given excellent service, their high initial cost being more than repaid in reduced maintenance and replacement.

Rotary filters can be made to withstand this and other similar corrosive slurries by using sulphur-impregnated cypress joined together with Hastelloy C bolts. Very good results have been obtained by making the valve and wear-plate out of Bakelite, as this material has good acid resistance, and the surfaces can be refinished when worn.

Brick linings are still being used where considerable erosion is encountered, or when free nitric acid or mixtures of nitric and hydrochloric acid must be handled. The linings are installed in concrete or in carefully dried soft wood vats. Where acids are handled, vats are preferable as leakage is at once apparent and can be stopped by pumping in water glass between the vat and lining. Rapid temperature changes must be avoided, and agitator drives should be installed on a superstructure to avoid vibration.

Concentrations of hydrochloric acid of less than 15 per cent at temperatures below 30 deg. C. are usually handled in

cypress vats. Above this temperature and at higher concentrations rubber-lined equipment is used wherever possible. This type of equipment has proved itself to be among the most satisfactory used in process work, not only because of its exceptional freedom from maintenance, and its low initial cost, but because it does not contaminate the product. Rubber-lined equipment cannot be used for nitric acid, and is not usually recommended for temperatures over 80 deg. C., but it can be made to withstand temperatures up to 110 deg. C. Hastelloy A is satisfactory for any concentration and temperature of hydrochloric acid, but its cost makes it prohibitive for large apparatus, and its most common use is for smaller parts such as pumps, bolts, agitators, etc. Hastelloy A is not as satisfactory as Hastelloy C when appreciable quantities of sulphuric acid are present. The latter alloy also has the advantage of resisting dilute nitric acid.

So far as tonnage is concerned, the acid and direct dyes lead all the others. These dyes are made by diazotizing one or more intermediates, and coupling in either acid, neutral, or alkaline solutions. Diazotization is accomplished by adding sodium nitrite to an ice-cold solution of an amine in either hydrochloric or sulphuric acid for acid couplings. In nearly all cases the acid solution is so weak that cypress vats give years of service. Monel bolts are satisfactory for fastening agitator arms, and outlets can be made of lead or Duriron.

#### Cypress Most Useful Wood

When vats are used for handling acids, cypress gives good service and is the wood most generally used. Yellow pine may be used for neutral or slightly alkaline solutions, but cypress is preferred. Lead lining is not required in vats where sulphuric acid is present in concentrations of less than 8-10 per cent cold, or less than 5 per cent hot. Hydrochloric acid can be handled in cypress up to 12-15 per cent hot or cold. Caustic solutions should never be handled in wood.

Fusion of an intermediate with flake caustic soda is the method most commonly used to replace a sulphonate group with an hydroxyl group. In addition to the intermediate and caustic, there is usually present in the fusion from 5-15 per cent of salt, and smaller varying quantities of sodium sulphate. When fusions are made at atmospheric pressure, cast iron gives excellent results, with temperatures up to 350 deg. C. Graphitic or grey iron is used here rather than the white iron employed for acid reactions. Occasionally, even traces of iron cause very poor yields as when beta amino anthraquinone and its derivatives are fused to form Indanthrene Blues. In this case either 5 per cent

nickel steel, Monel, or 18-8 chrome-nickel steel are used, depending on the temperature and type of equipment necessary. When the fusion of any intermediate is carried out under pressure, water is always present, the ratio varying from equal parts water and caustic down to one part water to five of caustic. For such fusions steel is preferred. With high temperatures the corrosion of steel may be appreciable, and in some cases nickel-steel autoclaves prove to be the most economical. It is always real economy to use Monel or 18-8 chrome-nickel steel for valve parts in contact with caustic fusion melts.

Filter-press plates and frames are always made of wood except in a few isolated examples where strong caustic solutions must be handled, when cast iron is used. When acid solutions are to be filtered it will always be found advisable to impregnate the plates and frames with paraffin. Ordinary canvas cloths are used when the acid concentration does not exceed 4 or 5 per cent; higher than this, mohair or nitrated cloths are used. With concentrations of over 20 per cent, these nitrated cloths always pay for themselves. When filtering crude Amino I and Amino G the cake is washed with a 40 per cent sulphuric acid solution, and in this service nitrated cloths have given over six months continuous service. With more dilute solutions they have been in use

for over a year without sign of deterioration. Pressure-filter leaves for filtering slurries containing sodium carbonate should be of copper bearing steel to reduce rusting, but where they can be justified, bronze, Monel, or stainless steel are preferable.

The majority of dyes are filtered out finally from an acid solution before drying, and the small amount of acid remaining causes a serious problem in the selection of suitable dryer pans. A material must be selected which will not contaminate the dye and for this reason steel cannot be used. Copper may be used in a few cases such as with methyl violet or victoria green, but the pan mortality is quite high. Enamel pans are ordinarily used with the high-priced vat colors, but they are expensive and chip readily because of the rough handling they receive. Wood pans are most commonly used with azo colors because of their cheapness, but they crack and break easily and cause considerable loss of color. A great number of materials have been tried in this service but Bakelite and Everdur seem to be the only materials which can be substituted with justification. Everdur will usually give better results where copper is now used, while Bakelite can be employed where wood or enamel are used.

Exposed steel piping deteriorates very rapidly in the moist acid conditions found in a dye plant, but it rarely pays

to keep these lines painted. Copper-bearing steel is preferred for all exposed piping, and its cost is very little more than ordinary pipe. Where double-pipe or tubular condensers are used, copper-bearing steel will outlast ordinary steel and should always be used.

At the present low cost of rubber, it is cheaper to use hose for all process lines handling only sulphuric acid below 80 deg. C. where iron is unsuitable. Above this temperature lead is better. With hydrochloric acid or mixtures of hydrochloric and sulphuric, rubber is advisable, even at higher temperatures, because of its low cost and ease of replacement. Hard rubber fittings need no longer be employed for press connections, hose couplings, vat outlets, etc., since rubber-lined steel is fully as resistant, with no danger of breakage.

What has hindered the more general introduction into the dye industry of expensive metals or alloys has been the fact that comparatively few products are manufactured in large enough tonnages to justify the capital expenditure necessary for their purchase. Since the same equipment setup is frequently used for as many as a half dozen products, it is very difficult to obtain true maintenance and depreciation costs on any one product. It can be done, however, and analysis of these true costs often will prove that "expensive" materials are actually the cheapest.



## NON-METALS HEAD LIST IN HCl RESISTANCE

**D**ISSOLVING hydrogen chloride gas in water is highly exothermic (17.4 cal. per gram) and contributes one of the most serious problems in the commercial production of HCl. In view of this extremely high heat of solution and the fact that solubility decreases with increasing temperature, it is apparent that the vital factor in the absorption of HCl gas is the removal of heat. Any absorption system that is to be efficient must of necessity be designed with heat removal as the main consideration.

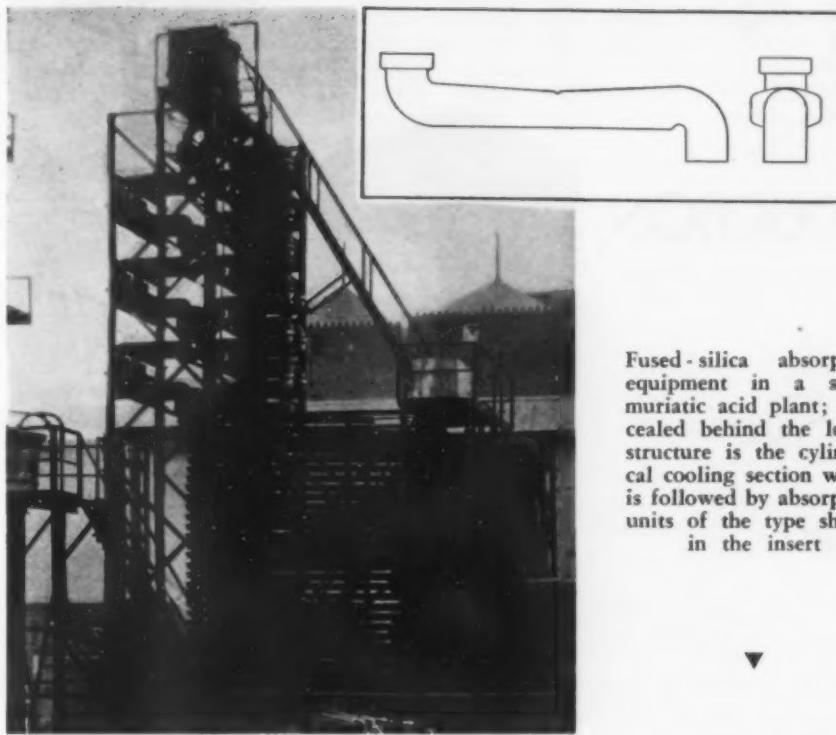
But the development of suitable construction materials for confining the gas during its cooling and absorption was not simple. Water solutions of HCl are among the most corrosive chemicals known. They attack all metals except the noble metals, forming chlorides all

By S. L. TYLER

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of which are soluble in water except those of silver, lead and mercurous mercury. Action on silver and lead is not sufficiently retarded by the presence of a chloride film to make the commercial use of these metals feasible except with very dilute acids. There are only a few materials in general use including stone, chemical stoneware, fused silica, rubber, glass, glass-enamelled steel, carbon refractories for strong acid, and wood for weaker acid. Most of these materials are employed in the use rather than in the production of HCl.

Hydrochloric acid gas is produced in several different ways but only four are of any considerable interest commercially. These include: the reaction between sulphuric acid or nitre cake and common salt; the direct union of hydrogen and chlorine by burning; the production of acid as a byproduct in the chlorination of organic compounds; and the reaction between chlorine, steam and hot carbon. The first of these is the oldest and was originally carried out with the intention of producing sodium sulphate which was marketed as such, crystallized to produce glauber salt or used in the Le Blanc soda process. The HCl given off by the reaction was largely a waste product and because of its affinity for water and the extremely corrosive nature of its solutions, was disposed



Fused-silica absorption equipment in a small muriatic acid plant; concealed behind the lower structure is the cylindrical cooling section which is followed by absorption units of the type shown in the insert

of in the simplest form of absorption equipment then available. This consisted of towers, ordinarily packed with coke and constructed of large sandstone slabs, which, obviously, were heavy and costly and because they permitted the dissipation of practically no heat, could not produce high-strength acid. To obviate these difficulties and to avoid contamination resulting from the leaching of the sandstone, towers of cylindrical, acid-resisting clay products were later developed, and were capable of giving a somewhat better acid by reason of partial dissipation of the heat. An elaboration of the tower method is still found under the name of the Zieren system.

Corrosion from HCl gas at high temperature is not as severe as is met with in solutions. The reaction between sulphuric acid or nitre cake and sodium chloride is carried out without a great deal of trouble in equipment constructed of cast iron and refractories. With the development of the electrolytic chlorine process, it was found expedient to combine the hydrogen and chlorine directly by burning. The furnace in this case consists simply of a fused-silica or brick-lined chamber in which the gases react and form HCl.

In the several methods, the HCl is evolved at a temperature too high to be dissolved in water. While it is still hot, the gas is not severely corrosive, but when the temperature drops below 110 deg. C., the maximum boiling point of HCl, the corrosion problem begins. Because of the impossibility of con-

structing cooling and absorbing equipment from metal, non-metals have always been chosen, ranging from the natural stone products, through chemical-stoneware equipment to the still more recent fused quartz. Earlier plants accomplished preliminary cooling in unglazed ceramic pipe, followed by a dry, packed tower to remove sulphuric acid which had distilled over with the HCl. The absorption towers used after the dry tower were later replaced with stoneware tourills in recognition of the need for better cooling in producing high-strength acid. Tourills operated on the principle of circulating liquor by undersurface flow and exposing a quiescent surface to the HCl-bearing gases.

In 1923, the author developed an absorption unit made up entirely of fused silica as is shown in the drawing inserted in the illustration. Fused silica is unaffected by HCl, by free chlorine or by a mixture of HCl and nitric or sulphuric acids. Absorption units of this type permit liquid overflow from the surface and give considerable agitation to improve absorption. Since the wall thickness averages only about  $\frac{1}{8}$  in. as compared with a wall thickness in towers as high as 6 in. or in stoneware, of about 1 in., it is obvious that the cooling capacity is high. An installation of fused-silica cooling and absorption equipment of this type is shown in the accompanying view. Unfortunately, accessory structures cover some of the plant but the scrubbing section, followed by the cooling equipment

and absorption system, can readily be identified.

In dealing with the usually less severe conditions of storage and use of HCl, it is often possible to apply other materials. In storage, the best practice today is the use of rubber-lined tanks of wood or steel. Prior to the development of satisfactory rubber linings, acid was stored in brick-lined wooden tanks with the lining grouted with sulphur, or in stoneware jars of capacities ranging to several hundred gallons. Small storage is sometimes effected in 10-gal. glass carboys which are also used in transportation. For transportation in larger quantities, rubber-lined steel tanks, mounted on automobile trucks, are used for moderate distances and for larger tonnages, rubber-lined steel tank cars. Some of the earlier rubber-lined wood tank cars are still in use.

Hydrochloric acid users, in general, are able to apply substantially the same storage methods as the manufacturers. In the use of HCl, however, considerable divergency exists as there is no single material which can be used satisfactorily for all purposes. Prices of materials differ widely, further complicating the choice, which, of course, must be made with reference to economic suitability. The metals, as a rule, present corrosion difficulties, the non-metals, fabrication problems. Of the totally or nearly totally resistant materials, fused silica, glass, glass-enamelled steel, chemical stoneware, rubber, tantalum and the alloy, Hastelloy A, may be mentioned. Entirely satisfactory pumps and similar parts have been constructed of hard-rubber, rubber-lined steel and stoneware. Pipe lines have been built of stoneware, glass, fused silica, hard rubber, rubber-lined steel and rubber hose. Stoneware and hard-rubber valves and cocks and rubber pinch-type cocks have proved satisfactory. Plant apparatus for stronger acid concentrations has been made of stoneware, hard rubber, rubber-lined steel, glass-enamelled steel, glass, fused silica, and occasionally of thin tantalum sheets.

Use of weaker acid solutions is somewhat simpler. Weak acid at room temperature has been handled satisfactorily with Illium G for small parts. Hastelloys C and D are reported useful with acid containing also sulphuric acid. Unlined wood tanks, preferably creosoted, or tanks lined with lead have been used to a large extent with weak HCl. Duriron has stood up well with weak acid at various temperatures and concentrated acid at room temperature. Nevertheless, where the greatest freedom from attack is required, even with acid of low concentration, the use of non-metallic construction materials is practically imperative.

# MODERN NITRIC ACID PRODUCTION DEMANDS SPECIAL ALLOYS

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NITRIC ACID manufacture by the pressure system of ammonia oxidation has been made commercially possible through the application of special alloys. The materials problems involved include: resistance to corrosion; resistance to scaling in highly oxidizing gases at elevated temperatures; prevention of contamination and decomposition of the materials in process.

With the cooperation of the research facilities of the metal producers and fabricators, much has been accomplished that a short time ago seemed almost impossible. Marked progress has been made in the production of corrosion-resisting alloys in rolled forms and tubes. Surface defects and laminations, once very common, are now comparatively rare, but meanwhile the resistance to attack in nitric acid, which is one of the most desirable qualities of the chrome alloys for this service, has fallen off. The average corrosion penetration recorded for samples recently tested is very much higher than the average obtained three years ago.

The ammonia oxidation process, which is described in an article by Taylor, Chilton and Handforth (*Ind. & Eng. Chem.*, Vol. 23, p. 861) is typical of the modern trend towards the economical application of metals and alloys; in addition to the common metals which are used wherever possible in equipment of this process, the following special metals are applied: nickel, high-silicon iron, 18 per cent chrome and 18 per cent chrome 8 per cent nickel alloys.

Nickel is generally used for parts in

Above: High-chrome alloys are used for the weight tank and pressure absorption tower in this nitric acid plant. Below: Chrome-alloy heaters and piping, with absorption tower appearing in the background

contact with ammonia vapors, or pre-heated air and ammonia mixtures, after these gases have passed through the filters, as its tendency to decompose ammonia at the operating temperatures is lower than most other metals. In the form of castings, forgings or seamless tubes, nickel is amply strong, but welded seams have not proved entirely satisfactory as failures have occurred where temperatures exceeded the operating range. Welded construction was used in the fabrication of tubes in sizes which were not available as seamless drawn, but it has been found desirable, as a safety measure, to reinforce all such welded tubes with steel clamps. In some cases tubes have been made by boring and turning from solid forged bars in preference to the use of welding.

#### Solving Catalyst-Holder Problems

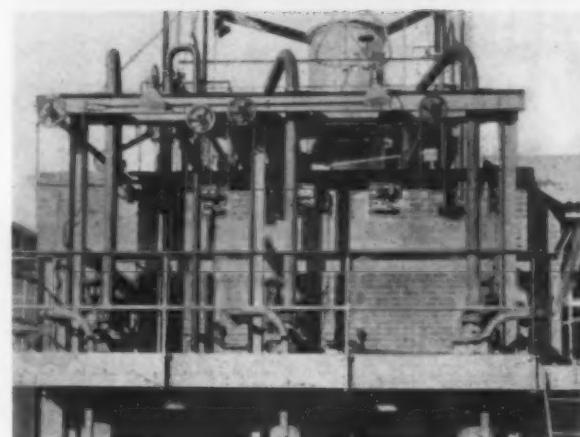
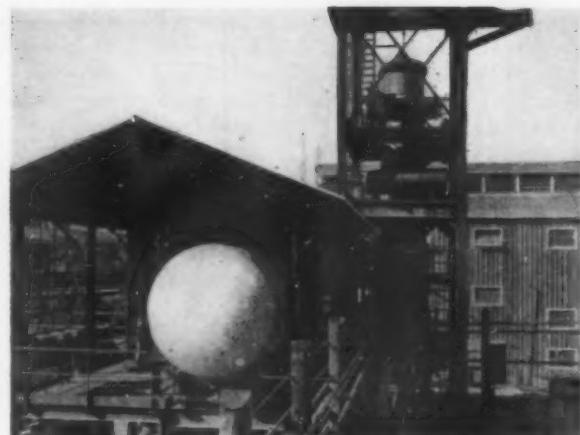
Some nickel catalyst holders, particularly the type carrying cylindrical gauzes, have scaled badly near the junction with the catalyst where the temperature approaches that of the reaction (1,650 deg. F.). For wrought-nickel holders it has been found that heat treating in steam at 950 deg. C. for 30 minutes forms an oxide film which retards the tendency to scale. In

later designs untreated cast-nickel alloys with 3 per cent silicon have shown better resistance to scaling than pure, forged nickel, heat treated.

**High-Silicon Irons**—For equipment used in concentrating nitric acid, above the strength (60-63 per cent) produced by the oxidation process, the high-silicon irons offer more satisfactory corrosion resistance; pressures in this process are relatively low and conditions favor the use of these somewhat brittle alloys. No particular difficulty is experienced with them if the designer has made proper provision for expansion and supports; and if care is exercised in bringing the apparatus up to working temperatures.

**Chrome Alloys**—After the conversion of the ammonia-air mixture to oxides of nitrogen in the converter, all equipment in contact with the gases or acids under pressure is made of some type of high-chrome alloy, either the straight 15-18 per cent chrome iron or 18-8 chrome-nickel alloy being used, depending on temperature and corrosion conditions or the fabrication difficulties encountered.

Cost and comparative ease of fabrication favor the use of 18 per cent chrome iron in the greater part of oxidation plant equipment, since it can



readily be obtained in sheets, plates, bars, seamless tubes, forgings and castings, and its resistance to corrosion is satisfactory except in one or two locations where conditions are extremely severe. With careful design, these conditions may be modified so that the 18 per cent chrome can be used throughout the system.

#### Casting Chrome Alloys Difficult

Since sound castings of chrome alloys are difficult to obtain, later designs have eliminated castings wherever possible; patterns which offered no unusual difficulty in steel foundry practice were found almost impossible to produce in this alloy, to meet the specified tests. Welding of defects is not permissible and foundry rejections were excessive; however the results obtained from accepted castings apparently justified the rejections. The foundryman should be consulted, and, if necessary, patterns modified to obtain the benefit of his experience. Corrosion resistance in samples from castings is comparatively poor, but the usual foundry practice calls for generous thickness and this to some extent compensates for more rapid corrosion.

Forgings are not entirely free from defects. A forged nozzle on a dismantled unit was found pitted almost

through the riveting flange; apparently a large inclusion had corroded out. Subsequent experience with some forged tube sheets which developed surface cracks indicated that such failures may be caused by neglecting to trim the billet cut-off properly when forging. These alloys do not hammer weld and projections forged in may form a fold or sliver which, with its accompanying embedded scale, is readily attacked by the acid.

The application of welded construction to chrome alloys in this process has been limited because of the difficulty in securing reliable corrosion-resisting welds. Recent improvements in welding technique have changed this condition and welding may be extensively adopted in future designs. Several all-welded vessels have been installed in other processes and are under observation.

Improper working may injure the structure of the chrome alloys. Hence, close control of all operations in fabricating is essential, since the condition of the metal has an important bearing on its corrosion-resisting qualities. Corrosion tests on heat-treated samples of 18 per cent chrome iron indicate that temperatures above 1,450 deg. F. should be avoided unless followed by annealing at not over 1,450 deg. We note, how-

ever, that certain laboratories specify annealing at 1,525 to 1,550 deg.

Cold working apparently also has an undesirable effect on these alloys for nitric acid service, as this has been evident in equipment in service. In an absorption column recently dismantled after 200 days in service producing acid, it was found that many internal caulked edges had fallen away and some of those remaining could easily be removed, although the plates and rivet heads showed no evidence of attack. A somewhat similar experience was partially responsible for the failure of vessels designed to vaporize nitric acid: caulked seams leaked after a few days in service and each recaulking of the joints extended the working life of the vessel for about a three-day period. In this case very special precautions were taken in fabrication: rivet holes were spot-faced and all fitting was as accurate as possible so that caulking was reduced to the minimum. This service was unusually severe and when the units were dismantled, local pitting was found on a number of rivet heads while adjacent rivets appeared to be in perfect condition. The plates did not show much evidence of attack until the rivets were removed, and then it was found that the edges of the plates and some rivet holes were pitted, in some cases as much as  $\frac{1}{8}$ -in. deep, while the adjacent surface showed no appreciable attack.

#### Chrome Irons for High Temperature

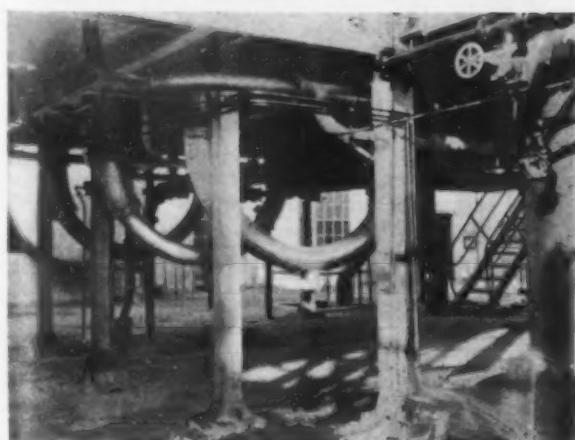
The 18-8 chrome-nickel alloy finds a limited application in the oxidation process. The heat-resisting qualities of this alloy caused its selection for service in air preheaters, but its unstable characteristics within a certain temperature range which is approximately equalled in this service, has caused some modification in later designs and has led to the substitution of 18 per cent chrome in parts formerly using the 18-8 alloys. Maintenance on these heat exchangers has been excessive on account of tube and tube-sheet failures.

The value of chrome alloys in nitric-acid work depends on their resistance to corrosion. During their early use in nitrocellulose equipment, it was observed that a large percentage of each lot of material installed soon had to be replaced because of failure by corrosion. Corrosion tests were developed to avoid the expense of installing and replacing material of inferior quality. This procedure is still followed and in general only approved material is used for plant construction.

Accelerated corrosion tests are made in boiling nitric acid of 65-per cent concentration, samples being submerged in acid or suspended in vapors. Every sample thus tested shows measurable



Above: Chrome-steel shell-and-tube condensers on top of the ammonia oxidation house. Below: View beneath the ammonia oxidation house showing jacketed chrome-steel lines carrying hot gas from the converters to the coolers



loss and this loss is continuous over any number of testing periods. Apparently the "protecting film" or "surface passivity" theories do not apply at these temperatures. Results of tests are calculated and tabulated in inches penetration for comparison. Since corrosion is seldom uniform, the actual depth of local pitting may be many times greater than the average penetration calculated from the accelerated test data.

Although these tests are nominally accelerated corrosion tests, conditions almost similar must be met in the oxidation process; the temperature gradient from the converter outlet to the absorption column inlet passes through the boiling range and the gases carry condensate in entrainment; the metal in contact with such gases must be in good condition and efficiently cooled to obtain a minimum corrosion rate.

Increased knowledge and improved facilities for the production of chrome alloys have not eliminated the need for corrosion tests. In a series of 90 tests

made a few years ago from different 18 per cent chrome heats, the highest penetration per year reported was 0.076 in., the lowest 0.017 in., and the average was about 0.035 in. These results are seldom matched today, in fact several samples tested recently have shown penetration of 1 in. per year.

#### Heat Treating, Working Affect Quality

With material of a given analysis the corrosion resistance may be varied by heat treatment; therefore, composition and heat treatment influence the results, but these are apparently not the only factors in the problem. An attempt was made three years ago to correlate data from a number of corrosion tests where all the information on analysis, heat treatment and working was available. The influence of individual constituents within the permissible range of specifications could not be traced but one important and somewhat surprising observation was made: where metal from the same heat was used in rolling  $\frac{1}{2}$ -in. and  $\frac{3}{8}$ -in. plate as well as sheets of  $\frac{1}{4}$  in. and  $\frac{1}{8}$  in.

thick, the corrosion tests on the sheets were invariably superior to tests from plate samples. This would indicate that the nature of the work done in rolling is a factor in producing good corrosion resisting quality.

With chrome alloys, quality must be worked into the material in every process from the melter, who may be responsible for dirty steel, to the roller who may injure the structure by excessive reductions per pass. While the product from a few mills is comparable to that produced earlier, when much trouble was experienced in overcoming the development problems, in general the accelerated corrosion tests indicate that the corrosion-resisting quality is inferior today and reflects what appears to be poor process control on the part of manufacturers.

Likewise, all working of the alloys in fabrication of equipment should be done under rigid specification, else high corrosion-resistance worked into the metals in preceding operations may be reduced or destroyed by poor workmanship.



## CORROSION LOOMS LARGE IN SULPHURIC ACID PLANTS

By J. J. HEALY, JR.

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AS THE MOST ubiquitous of all chemical reagents, sulphuric acid is a material to the handling of which much thought has been given. It is a general rule that sulphuric acid of strengths above 100 per cent (oleum) may be handled in steel. Hot acid of 66 deg. Bé. to 100 per cent calls for cast iron and cold acid in the same range, steel. Acid of 60-66 deg. is handled hot in cast iron or steel while lead is satisfactory for cold acid. Below 60 deg. lead is the material most generally used. Where a choice is indicated above, temperature conditions or the presence of dissolved gases will govern and it is often hard to make a choice. The materials mentioned are cheapest from every standpoint for the large user, but for the small consumer, who is usually more interested in preventing contamination of his product than he is in corrosion to equipment, special alloys are often of interest.

In the following I shall indicate the materials that I know have proven satisfactory in various cases. Undoubtedly other materials can also be used.

*Chamber Process*—Glover towers handle 55-60 deg. acid with temperatures of 70-100 deg. F. at the top, approaching the boiling point at the bottom. The nitre content may be up to 1 per cent  $N_2O_4$  at the top, while the acid at the bottom is nitre-free. Satisfactory towers are made of lead, lined with acid-proof brick. Pipe lines and coolers for the hot acid present a problem. We have used Duriron pipe with some success, but have always used lead coils and coolers. These have best served our purpose, but are a long way from perfection.

So far as I know, lead is the only material that has ever been tried for conventional chambers. It is quite satisfactory and reasonable in first cost. The front and back chambers are the most seriously affected, the front because of temperature and the back on

account of occasional nitric acid formation.

The Gay Lussacs generally circulate a comparatively cold 60-deg. acid at 70-100 deg. F. Nitre content ranges from 0 to 1 per cent  $N_2O_4$ . Lead towers lined with acid-proof brick are in general use. Gay Lussac acid is most often handled in lead pipe and lead-lined wooden tanks, but corrosion is very appreciable. Hard lead may be used for pumps and similar equipment where structural features require it but this material is not as resistant to corrosion as soft lead.

*Contact Process*—In plants of this sort one encounters all strengths of acid over a wide range of temperature. In the purification equipment, acid up to 55 deg. Bé. is used for cooling at temperatures up to 200 deg F. Lead is the material in general use for towers, pipe lines, pumps and valves. If the acid is strong and hot, the tower must be lined with brick. Acid mist elimination is by either coke boxes or Cottrells and produces a cold acid of 10-20 deg. Bé. This can be handled in lead.

In the dry towers, acid concentration ranges from 60 deg. to 98 per cent, running as high as 150 deg. F. in temperature at the bottom. For acids up to and including 66 deg., a lead tower lined with acid-proof brick is satisfactory. For strong acid, cast-iron or steel towers may be used and the latter should be brick-lined. Hot acid of concentrations between 60 and 66 deg. is a mean customer to handle. There is little choice between lead and cast iron. Neither is entirely satisfactory. Lead valves are the best but they are far from perfect. Acids of 66 deg. to 98 per cent are handled in cast-iron pipe and cast-iron pumps with cast-iron impellers. We have found that Pioneer metal valves are most satisfactory.

In the 98 per cent absorbers, the acid will run from 97.5 to 99.5 per cent with temperatures up to 200 deg. F. Steel towers lined with acid-proof brick are most satisfactory although unlined cast-iron towers might be used successfully. Cast-iron piping, cast-iron pumps with cast-iron impellers, steel storage tanks and Pioneer metal valves complete the picture.

Oleum absorbers operate at temperatures up to 200 deg. F. with 98 per cent acid at the top and 25 per cent oleum at the bottom. They are generally made of brick-lined steel. Pipe, storage equipment and valves are of steel. Steel valves are used because of their cheapness, although they are not entirely satisfactory. Cast-iron pumps with cast-iron impellers are used.

In the production of 60 per cent oleum, 25 per cent oleum is distilled in cast-steel stills and the SO<sub>2</sub> absorbed in monohydrate in a steel tank equipped with steel cooling coils. All pipe is cast iron. Monohydrate is about the worst acid to handle from a corrosion standpoint. We have no material that is entirely satisfactory for it.

In view of the low iron specifications for battery acid, this material is usually made as 66 deg. in fused silica equipment.

Because of the large quantity of iron equipment used in contact plants, very close attention must be given to leaks, splashes and spills. Strong acid in contact with iron and the atmosphere absorbs moisture readily, becomes diluted and rapidly attacks the metal. Consequently, leaks must be prevented, spills immediately washed down, and all equipment kept well covered with an acid-resistant paint.

**Storage**—Methods of acid storage depend on the strength. Cold acid up to 66 deg. Bé. should be stored in lead-lined steel or wooden tanks. Strengths above 66 deg. are stored in steel. Pipes, pumps and valves made from the same metal as the interior of the tank are satisfactory. It is often more convenient for the small user to employ

alloy equipment such as Duriron in place of lead, because replacements are much more easily made. Battery acid of 1.835 specific gravity should be stored in earthenware or enameled tanks. Strengths in the neighborhood of 1.200 may be stored in lead.

As all steel tanks generate some hydrogen in contact with sulphuric acid, open lights must be kept away. Care must be taken to avoid contact with the atmosphere when acid is stored in steel. Tanks should be kept tightly covered and all spills washed off immediately. Steel valves at the end of an acid line should always be protected from the action of the air. Discharge through a lead U tube will insure the presence of a strong acid in contact with the valve.

In shipment, acid of 55 deg. Bé. and stronger may be handled safely in steel tank cars. Drums, however, on account of their lighter construction, can be used only for acid of 66 deg. and above. The only exception is in the case of certain inhibitor acids whose action is no more severe than that of 66 deg. The same remarks apply to steel drums and tank cars as to steel tanks. Drums should have the bungs removed once a week to relieve pressure and should be stored out of the sun. Glass carboys are the only packages available for weaker acids and for battery acids.

#### Materials for Acid Use

In the petroleum industry, the treatment of distillates with sulphuric acid is carried out in lead-lined steel tanks. Separation and concentration of sludge acid requires lead lining. Corrosion in stills and pipe lines, as a result of sulphuric acid formed by the oxidation of sulphur compounds, is prevented by the addition of caustic soda or ammonia.

Scale removal in the steel industry is commonly accomplished by pickling in a 2-10 per cent solution at a temperature of 180 deg. F. Wooden tanks are in general use. The tierods must be of material not subject to corrosion, such as bronze or Monel metal. Concrete tanks lined with acid-proof brick are coming into favor where there is no serious danger of damage due to abrasion. With certain types of inhibitor acids, iron tanks have been used successfully. One very important problem in pickling is the protection of building steel and overhead equipment for which protective paints are essential.

Textile industries are users of considerable quantities of sulphuric acid. A dilute solution is employed in the carbonizing and dyeing of wool. Carbonizing solutions are generally cold with 5-15 per cent acid content. Wooden tanks are satisfactory, held together with bronze or Monel metal tierods. For piece carbonizers, the rolls are rubber-covered. Care must be taken to protect iron cores of rolls and iron parts

on carbonizing rolls. In mills that extract the goods after immersion in the carbonizing liquor, it is essential that corrosion-resistant materials be used for the extractor basket. Many spot troubles can be traced to disregard of this requirement.

Coagulating baths in the viscose rayon process contain 10-20 per cent of sulphuric acid. The bath trough is usually made of lead and the spinnerets of platinum, tantalum, noble metal alloys or occasionally glass. Lead covering is largely used for protection of spinning machine parts. Other parts such as hooks, godets, pots, funnels and bobbins have been made of a variety of non-metals including glass, hard rubber, Bakelite, and porcelain. Protected aluminum has been used to a considerable extent for pots and bobbins.

One of the principal corrosion problems of the leather industry is the obtaining of suitable materials for resisting a strong mixture of bichromate of soda and sulphuric acid. Lead is used but without entire satisfaction.

In the more strictly chemical industries, a wide variety of problems are presented. In the group which employs sulphonation, including the sulphonation of oils and the manufacture of dyestuffs and intermediates, no iron-clad rule can be applied on account of the wide variation in the types of sulphonation carried out. As a general proposition, it may be stated that where the strength never falls below 66 deg., iron is suitable. However, there are many sulphonations that start above 66 deg. and end well below it. The solution of this problem is probably brick lining so far as the container is concerned. In any event, corrosion will probably play havoc with stirrers and coils. Brass may be of assistance in such cases.

In the heavy chemical industries, the construction materials are generally the ordinary ones. In alum, ammonium sulphate and acetic acid manufacture, lead-lined equipment is used; in nitric acid, steel. Muriatic is a special case and to obtain a product low in iron requires the use of ceramic or fused-silica equipment.

No mention has been made of the acid salts including nitre cake, alum and ferric sulphate. The first two in solution are generally treated as weak sulphuric acid solutions, using wood or lead-lined equipment. In the dry state, they differ in one important respect. Nitre cake cannot be handled in bags although alum can, provided it contains a slight excess of alumina. The third, ferric sulphate, is both an oxidizing agent and acid salt. In the dry state it can be handled similarly to alum, but it offers difficult problems when in solution. Lead lining is perhaps most satisfactory and rubber is sometimes suitable.

# WHERE STAINLESS ALLOYS STAND IN CHEMICAL CONSTRUCTION

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CHEMICAL INDUSTRIES have long sought materials of construction resistant to corrosive action. No single material or alloy, equally adaptable to all purposes, has ever been produced. But in pursuit of permanence as an ideal, the development of alloys of chromium and iron, with or without nickel, has made available a class of materials combining unusual resistance to corrosion with desirable physical properties. It is estimated that at the present time there is in service from 7,000 to 8,000 tons in the form of chemical-plant equipment.

Chemical engineers have applied stainless steels to the construction of equipment for a variety of service. These applications are generally based on efforts to meet one or more of the following specific requirements: (1) Severely corrosive service at moderate temperatures where the expected life of the equipment is the most important consideration. (2) Prevention of contamination of the product to be handled by the equipment. (3) Resistance to high

temperature (resistance to deterioration and retention of strength). (4) General mechanical requirements.

Stainless steels admirably fulfill these requirements in many cases. Because of their corrosion resistance they frequently can be used to eliminate all contamination of the product being handled. Where high-temperature service is involved, both their corrosion-resisting nature and their high-temperature properties are of the best. As a class they lend themselves to ready fabrication in a manner similar to steel. There are, however, certain limitations in fabrication of these alloys which will be discussed later. They can be welded by all

the usual means except hammer welding, although for many forms of chemical-plant equipment, electric-arc or atomic-hydrogen welding are to be preferred to acetylene welding.

In consulting corrosion-resistance tables for the various stainless alloys, it should be remembered that the results given are to be considered only as tentative and for guidance, since they are based on laboratory tests which may not duplicate the exact conditions to be encountered in the proposed service. Briefly, these laboratory tests and actual service installations indicate that the stainless steels can profitably be given consideration for practically all corrosive conditions except those involving the halogen acids and sulphuric acid. They stand up particularly well when subjected to nitric acid of any concentration or to other oxidizing agents. Even though they are never recommended where the corrosive medium is pure sulphuric acid, some of them show almost perfect resistance to certain mixtures of sulphuric acid with nitric acid,

Comparison of Chromium-Iron and Chromium-Nickel-Iron Alloys on Basis of Analyses and Properties

	(A) 11-15 Per Cent Chromium Stainless Alloys		(B) 16-20 Per Cent Chromium Low Carbon Iron Alloys	(C) 25-30 Per Cent Chromium Stainless Alloys		(D) 16-8 Chromium-Nickel Steel	(E) 25-12 Chromium-Nickel Steel
	High Carbon	Low Carbon					
General Composition, Per Cent							
Chromium.....	11 to 15	11 to 15	16-20	25-30	16-20	22-28	
Nickel.....	0.50 max.	0.50 max.	0.50 max.	0.50 max.	7-10	12-16	
Carbon.....	0.35 to 0.50	0.10	0.10 max.	0.25 max.	0.15 max.	0.25 max.	
Silicon.....	0.50	0.50	0.50 max.	0.50 max.	0.75 max.	1.00 max.	
Manganese.....	0.50	0.50	0.50 max.	0.50 max.	0.75 max.	1.00 max.	
Phosphorus.....	0.025	0.025	0.025 max.	0.025 max.	0.025 max.	0.025 max.	
Sulphur.....	0.025	0.025	0.025 max.	0.025 max.	0.025 max.	0.025 max.	
Typical Properties					Fully Annealed		
Ultimate Tensile Strength, Lb. per Sq. In.....	240,000	141,000	125,000	60,000	75,000	80,000	90,000
Yield Point, Lb. per Sq. In.....	126,000	100,000	35,000	40,000	50,000	30,000	50,000
Elongation, per cent in 2 in.....	9	15	20	25	25	15 to 25	40
Brinell Hardness.....	444	285	230	150	175	180	135
Elastic Modulus.....	29×10 <sup>10</sup>	29×10 <sup>10</sup>	29×10 <sup>10</sup>	29×10 <sup>10</sup>	29×10 <sup>10</sup>	29×10 <sup>10</sup>	29×10 <sup>10</sup>
Density, Lb. per Cu. In.....	0.281	0.281	0.281	0.281	0.277	0.274	0.283
Approx. Scaling Temperature, Deg. F.....	1,250	1,250	1,300	1,300	1,600	2,150	1,650
Thermal Conductivity, Cal./Cm. <sup>2</sup> /Sec.....	0.07-0.08	0.07-0.08	0.07-0.08	0.07-0.08	0.07-0.08	0.06	0.05-0.06
Coefficient of Thermal Expansion per Deg. F.*.....	0.0000063	0.0000063	0.0000063	0.0000063	0.0000061	0.0000056	0.0000089
Available Forms†.....	B,F	A	A	P,S,R,B,W,S&T,C,F	A	P,S,R,B,S&F,C	

\* Range 32-212 deg. F.

† Key to available forms: A, all forms in which steel is commonly furnished; B, bars; C, castings; F, forgings; P, plates; R, rods; S, sheets; Sh, shapes; T, hot-rolled tubes; W, wire.

copper sulphate or ferrous sulphate. It may be said that the stainless steels are relatively less affected by the impurities usually present in solutions used in chemical plants, aside from halogen-compound impurities, than other metals or alloys. In fact, impurities or secondary components in solutions frequently act as inhibitors.

In considering what the stainless steels offer in meeting chemical equipment requirements, we must first realize that there are two series of alloys, one of chromium and iron and the other of chromium, nickel and iron, which are included under the generic term of "stainless." These alloys can be classified approximately into five principal subdivisions: the chromium steels of 11-15, 16-20 and 25-30 per cent chromium content; and the 18-8 and 25-12 chromium-nickel steels. Typical compositions and properties of these steels are shown in the tabulation.

#### (A) 11-15 Per Cent Chromium Stainless Alloys

This general classification is subject to further subdivision on the basis of carbon content as appears in the table. The high-carbon alloys are generally used only where their hard, tough mechanical properties are particularly desirable. They are seldom if ever used in forms other than bars or forgings. Because of their high carbon content, they must be used in the hardened or hardened-and-tempered conditions, or else considerable corrosion resistance is lost. They have successfully served the chemical industry where wear resistance and hardness are necessary.

The low-carbon 11-15 per cent chromium alloys have found a variety of uses in the chemical industry even though they are, except for the high-carbon alloys of this group, the least corrosion resistant of the stainless-steel series. They have been used for nitric acid equipment in handling the more concentrated acids.

The low-carbon 11-15 per cent chromium alloys, being available in practically all forms obtainable in steel and having, in the annealed state, forming characteristics similar to those of steel, allow the equipment designer a range of freedom. Difficulties in fabrication arise, however, since the material is distinctly air hardening which sometimes eliminates welding as a means of construction, although it is possible to obtain ductile welds if annealing after welding can be accomplished. The air-hardening properties of these alloys make it necessary to use care in hot riveting. The rivets should not be heated higher than 1,475 deg. F.

Because of the high strength and toughness of these alloys, together with relative ease in machining, they are suit-

able for nuts, studs, and bolts which must be corrosion-resisting.

Although these alloys can hardly be classed as heat-resisting steels they maintain their strength at high temperatures (particularly up to 1,100 deg. F.) far better than ordinary steel and up to their scaling point (1,300 deg. F.) they have high resistance to oxidation and to corrosion by sulphur compounds.

#### (B) 16-20 Per Cent Chromium, Low-Carbon Alloys

Of all the stainless steels, these alloys have found the largest tonnage application in the chemical industry. The equipment for atmospheric nitric-acid plants has been largely built from alloys of this group. From a corrosion-resistant standpoint, they are appreciably better than the alloys discussed above. They withstand almost perfectly the action of all concentrations of nitric acid and generally offer a satisfactory resistance to many other corrosive agents, notable exceptions being sulphuric, sulphurous, halogen, phosphoric and tartaric acids.

The mechanical properties of these alloys, together with the availability of the material in all forms commonly obtainable in steel, allow them to be used in equipment of almost any design that might be built of steel. They cannot be hardened appreciably by thermal treatment. Under some conditions however, they are subject to grain growth at elevated temperatures which results in a tendency to brittleness. For this reason, welding is seldom used except where welds will not be subjected to great stresses or shock loads.

When these alloys are welded with rods of the same composition, annealing after welding is essential. If they are welded with 18-8 chromium-nickel-steel welding rods rather than with rods of the same composition, more ductile welds result, which for certain purposes have proved satisfactory without annealing. When welding of this kind is contemplated, consideration should be given to the fact that the 18-8 alloy used for filler rod has an expansion approximately 50 per cent greater than 16-20 per cent chromium-alloy steel. Using 18-8 for welding generally offers no difficulty from the standpoint of resistance to corrosion although a corrosion test of a sample weld is worth while if corrosive media are to be handled.

While hot riveting of the 16-20 per cent chromium alloys formerly represented a difficult task, it is now accomplished by a number of experienced fabricators and excellent results obtained. Tank cars for transporting nitric acid have been constructed of this alloy by hot riveting and have shown excellent service.

These alloys offer excellent resistance

to oxidation and general high-temperature corrosion service, particularly high-temperature sulphur corrosion, at elevated temperatures up to their scaling point—approximately 1,600 deg. F. At temperatures up to 1,300 deg. F., they have appreciably higher strength than steel. In so far as corrosion resistance is concerned, they do not undergo any change on being held at high or intermediate temperatures. The grain growth occurring at high temperature, however, seriously decreases their toughness. Moreover, if these alloys are held for appreciable lengths of time, hundreds of thousands of hours, in the temperature range of 800 to 1,100 deg. F., and then cooled from this temperature, they are found to be quite brittle and to have little resistance to shock loads at room temperature. If after the service at 800 to 1,100 deg. F. the material is held for a short period of time, 30 to 60 min., at 1,400 to 1,500 deg. F. and then cooled, this brittleness is not evidenced.

#### (C) 25-30 Per Cent Chromium Stainless Alloys

Alloys in this range, although characterized by a high resistance to corrosion which is appreciably better in most cases than the 16-20 per cent chromium alloys, are generally used only when advantage is to be taken of their resistance to high temperature. Due to difficulties encountered in fabrication, they are used for wet corrosive service only where they are appreciably superior to other members of the stainless-steel series.

Notwithstanding the indications of high ductility shown in mechanical tests, these alloys can be severely formed cold only with difficulty. In common with the 16-20 per cent chromium alloys, the 25-30 per cent group cannot be hardened appreciably by thermal treatment. Another similarity to the 16-20 per cent chromium alloys is that prolonged heating at high temperatures results in the formation of a large grain structure which greatly reduces the toughness. Welding is commonly resorted to in fabricating equipment from these alloys. Welding rods of the 25-12 (25 per cent chromium, 12 per cent nickel) austenitic alloy are in some instances used when welding the 25-30 per cent chromium alloys.

Of the alloys commonly offered for heat-resisting purposes, the 25-30 per cent chromium alloys possess the greatest resistance to oxidation and to sulphur-bearing gases and have the highest scaling temperature. Because of economic considerations, they are generally used for high-temperature service only where the working range of temperature is between 1,500 deg. F. and the scaling point, 2,150 deg. F.; for

working temperatures not exceeding 1,500 deg. F. (100 deg. F. being allowed as a factor of safety) the 16-20 per cent alloys are generally used. Although these 25-30 per cent chromium alloys do not offer as great high-temperature strength and toughness as do the chromium-nickel alloys, they find wide application, particularly in cases where maximum strength and toughness are not necessary and where the service is intermittent. The relatively low coefficient of expansion of these alloys allows the protective high-temperature oxide formed on the surface to remain intact even where the metal is subject to intermittent heating and cooling.

In common with the 16-20 per cent chromium alloys, these alloys undergo no changes which appreciably affect their corrosion resistance on being held at intermediate temperatures. However, they are apt to be quite brittle at room temperature after exposure for prolonged periods at high temperatures.

#### (D) 18-8 Chromium-Nickel Steels

Alloys of this range are commonly known as 18-8 and are the most widely used of any of the stainless steels. The nickel content not only causes the material to be more corrosion resistant to a wider range of media but also confers a marked degree of toughness. It is the combination of marked resistance to corrosion in a variety of environments, the inherent toughness and strength, and the relative ease and range of fabrication that makes the 18-8 alloys the answer to many of the chemical engineer's problems. The 18-8 steels find application for equipment for the manufacture and handling of nitric acid, mixed acids, acetic acid, ammonium nitrate, glauber salt, bleach liquors and many other solutions. They have also successfully served for the severe abuse accorded to shipping containers.

These alloys as normally shipped by the producers are single-phase alloys (true solid solutions) as a result of the final annealing treatment which consists of heating to temperatures of 1,850 to 2,150 deg. F., followed by rapid cooling. The annealed material is non-magnetic. It does not respond to hardening by thermal treatment but hardens rapidly upon cold working, becoming thereby somewhat magnetic, depending upon the degree of cold work.

In designing equipment to be fabricated from these alloys, it is necessary to consider carefully the mechanical properties. It will be noted that the 18-8 alloys have high tensile strengths, and high elongations, but the moduli of elasticity and the yield points are no higher than for plain steel. The high tensile strength combined with the relatively low yield point (an indication of extreme toughness) is particularly

marked in the case of 18-8 alloys with low carbon content which, because of their greater resistance to corrosion, are being more and more favored for chemical equipment. Cold working will raise the yield point rapidly (20 per cent cold reduction will increase the yield point from the range of 30,000 to 45,000 lb. per square inch for the annealed material to approximately 140,000 lb. per square inch for the cold-worked material) but the use of cold-worked material for chemical-plant equipment has not found general use due primarily to difficulties encountered in production and fabrication.

Another property of the 18-8 alloys that should receive consideration in designing equipment is the coefficient of thermal expansion which is approximately 50 to 60 per cent greater than that for steel. In designing welded apparatus, it is advisable to locate the welds so as to mitigate the difficulties with expansion during the welding operation and to prevent undue strains from being set up by the welding.

Since the 18-8 lends itself readily to welding and the welds are strong and tough, welding is commonly used in fabricating this alloy. However, when these alloys are heated to the temperature range of 800 to 1,450 deg. F., they may undergo a change which affects their corrosion resistance to certain media (intergranular corrosion). In welding, it is inevitable that some of the metal will be heated only to 800-1,450 deg. F. and cooled from these temperatures. The reduction of corrosion resistance resulting from heating 18-8 within this range can be overcome if the material is subsequently heated to 1,700-2,150 deg. F. (depending on the carbon content) and quickly cooled. Where it is impractical to employ heat treatment after welding or other exposure to damaging temperatures, a modified alloy should be employed to avoid this difficulty. Several modified alloys have been developed, of which the outstanding one of commercial value today is the 18-8 containing titanium.

It should be understood that special developments to overcome intergranular corrosion on welding are primarily concerned only with equipment for severe service. The carefully annealed, low-carbon 18-8 now made should prove satisfactory for general purposes and, therefore, should be used, reserving special developments such as the titanium-bearing 18-8 for equipment where welding is involved and where the corrosive service is extremely severe.

In addition to finding a wide variety of applications for resistance to wet corrosion, 18-8 is important as a heat-resistant alloy. From the standpoint of retaining its strength and toughness at elevated temperatures, few metals or

alloys are its equal. At 1,200 deg. F. it has a creep stress (stress necessary to produce 1 per cent elongation in 100,000 hours) approximately ten times that of plain steel. Up to its scaling point, 1,650 deg. F., it offers exceptionally good general resistance to oxidation and corrosion by industrial gases. It has, therefore, been used extensively where a strong, tough, heat-resistant alloy is required. If the operating temperatures are in the range of 800-1,450 deg. F. and the exposure is to corrosive gases, intergranular corrosion may be encountered, particularly where the material is subject to stress. In service in the critical range of temperature, very low-carbon varieties of 18-8 (0.07 per cent max. carbon) are more stable than are the regular 18-8 alloys. The maximum resistance to intergranular corrosion when operating at temperatures of 800 to 1,450 deg. F., is obtained when the cold-worked 18-8 or the titanium-bearing 18-8 is used. These materials appear to be free from intergranular attack and to be the best of the metals or alloys offered for high-temperature service.

#### (E) 25-12 Chromium-Nickel Steels

The alloys of this range, in common with 25-30 per cent chromium alloys, find only limited application, principally because they are more expensive than the other alloys of the stainless series. Their main application is for heat resistance between 1,500 and 2,100 deg. F., although their high percentages of chromium and nickel cause them to be excellent corrosion-resisting materials, perhaps the best of the alloys in the stainless series. In common with the 18-8, they are strong and tough at elevated temperatures. They show excellent resistance to oxidation and to corrosion by industrial gases at temperatures up to the scaling point, 2,100 deg. F.

Although the regular 25-12 alloys, in common with other regular chromium-nickel alloys, show carbide precipitation, and consequent liability to intercrystalline corrosion when held at 800-1,450 deg. F., the time necessary to cause appreciable precipitation is very much longer than for 18-8. For high-temperature applications, carbide precipitation is seldom of great moment in the case of 25-12 alloys since they are largely used at temperatures above the precipitation range.

These alloys can be readily fabricated. Metallurgically, they are quite similar to 18-8 and, as we would expect, their fabricating characteristics are similar. Unfortunately, because of the toughness of the material even at extremely high temperatures, seamless tubes of these alloys are not available. However, welded tubing can be readily obtained.

# MODERN METALS



For Corrosion, Heat and Abrasion Resistance

CHEM. & MET.

SEPTEMBER, 1932

AS A MEASURE of the recent and rapid progress that has been made in the manufacture and utilization of corrosion resisting metals, it is interesting to note that this issue of *Chem. & Met.* data sheets records the properties of more than 250 different metals and alloys as compared with 115 in the September, 1929, compilation and 75 in the original A.S.T.M. sheets in 1924. Likewise, more extended use of these modern metals has broadened the knowledge and experience of the manufacturers so that we are now privileged to present their recommendations for almost 100 corrosive chemicals, —as compared with fewer than a dozen in both of the earlier compilations.

In presenting this information to *Chem. & Met.* readers, the editors wish to repeat and strongly re-emphasize the warning against the misuse of corrosion data, par-

ticularly of laboratory findings that seldom, if ever, duplicate actual operating conditions of service. At best these should be used only as an indication as to whether or not service tests or trial installations are advisable.

The recommended applications for cor-

This is a revision and expansion of the Metals and Alloys section of "Materials of Construction for Chemical Engineering Equipment," originally published as an editorial supplement to the September, 1929, issue of *Chem. & Met.* and subsequently reprinted and widely distributed in process industries.

## MATERIALS RECOMMENDED BY MANUFACTURERS FOR USE WITH CORROSIVE CHEMICALS

<b>ACETIC ACID (Very dilute):</b> Admiralty, 12; Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Bethadur 1, 70; Bethadur 2, 71; Bethadur 4, 72; Bethalon, 76; Chemical Lead, 3; Chromax, 89; Chromium Iron, 93; Circle L 22, 106; Circle L 23, 107; Circle L 31, 109; Cyclops 17 Metal, 122; Defistain, 126; Deoxidized Copper, 4, 5 & 6; Duraloy N, 129; Duro Glass C 2, 133; Duro Glass C 3, 134; Durimet, 131; Duriron, 132; Elecomet-K, 135; Empire 30, 140; Everdur, 28; Fahrte N 2, 152; Fine Silver, 7; G-60, 29; Hardware Bronze, 30; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; Heat Resisting St. 5, 159; Highloss C, 160; Highloss DD, 161; HR-5M, 162; Hy-Glo, 163; Illium, 35; Lesco 18-8, 164; Lesco 18-8S, 165; Lesco 21-12, 166; Lesco 25-20, 167; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Mechanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy A, 181; Midvaloy 26-02, 179; Midvaloy 30-30, 180; Misco C, 184; Monel Metal, 37; Nevastain KA 2, 187; Nickel, 10; Nickel Clad Steel, 192; Nickel Silver, 18% A, 41; Nickel-Silver 18% B, 42; Nichrome, 190; Nichrome IV, 39; Ni-Resist, 194; Nirosa KA 2, 199; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze 30, 45; Omega Phos. Bronze 209, 47; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; R-50, 54; Red Brass, 55; Red Brass 85%, 56; Regular SS, 210; Resistal, 57; Rezistal 2C, 215; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2600, 214; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Sivyer 60, 218; Stainless Iron, 226; Stainless Iron 2 F. M., 227; Stainless Iron 16, 229; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Stellite 1, 58; Stellite 6, 59; Stellite 12, 60; Sterling Nirosta, 236; Sterling Stainless St. FC, 237; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; Tophet A, 63;	Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Stuf, 64; USS 12, 249; USS 17, 250; USS 18-8, 251; US.S. 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.
<b>ACETIC ANHYDRIDE:</b> Admiralty, 12; Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 38, 1; Alciad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Bethadur 2, 71; Chemical Lead, 3; Defistain, 126; Defistain, 126; Deoxidized Copper, 4, 5 & 6; Durimet, 131; Duriron, 132; Durco Nirosa, 130; Duro Glass C 2, 133; Duro Gloss C 3, 134; Elecomet K, 135; Empire 30, 140; Everdur, 28; Fine Silver, 7; Fahrte N 2, 152; G-60, 29; Hardware Bronze, 30; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; Heat Resisting St. 5, 159; Highloss C, 160; Highloss DD, 161; HR-5M, 162; Hy-Glo, 163; Illium, 35; Lesco 18-8, 164; Lesco 21-12, 166; Lesco 25-20, 167; Mechanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 30-30, 180; Misco C, 184; Monel Metal, 37; Nevastain KA2, 187; Nickel 10; Nickel Clad Steel, 192; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nirosa KA2, 199; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; R-50, 54; Red Brass, 55; Red Brass 85%, 56; Regular SS, 210; Rezistal 2C, 215; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal KA2, 216; Rezistal KA2Mo, 217; Sivyer 60, 218; Stainless Iron, 226; Stainless Iron 2 F. M., 227; Stainless Iron 16, 229; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Stellite 1, 58; Stellite 6, 59; Stellite 12, 60; Sterling Nirosta, 236; Sterling Stainless St. FC, 237; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Stuf, 64; USS 12, 249; USS 17, 250; USS 18-8, 251; US.S. 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.
<b>ACETONE:</b> Admiralty, 12; Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 38, 1; Alciad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Bethadur 2, 71; Chemical Lead, 3; Defistain, 126; Defistain, 126; Deoxidized Copper, 4, 5 & 6; Durimet, 131; Duriron, 132; Durco Nirosa, 130; Duro Glass C 2, 133; Duro Gloss C 3, 134; Elecomet K, 135; Empire 30, 140; Everdur, 28; Fine Silver, 7; Fahrte N 2, 152; G-60, 29; Hardware Bronze, 30; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; Heat Resisting St. 5, 159; Highloss C, 160; Highloss DD, 161; HR-5M, 162; Hy-Glo, 163; Illium, 35; Lesco 18-8, 164; Lesco 21-12, 166; Lesco 25-20, 167; Mechanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 30-30, 180; Misco C, 184; Monel Metal, 37; Nevastain KA2, 187; Nickel 10; Nickel Clad Steel, 192; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nirosa KA2, 199; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; R-50, 54; Red Brass, 55; Red Brass 85%, 56; Regular SS, 210; Rezistal 2C, 215; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal KA2, 216; Rezistal KA2Mo, 217; Sivyer 60, 218; Stainless Iron, 226; Stainless Iron 2 F. M., 227; Stainless Iron 16, 229; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Stellite 1, 58; Stellite 6, 59; Stellite 12, 60; Sterling Nirosta, 236; Sterling Stainless St. FC, 237; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.	Stuf, 64; USS 12, 249; USS 17, 250; USS 18-8, 251; US.S. 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.

MODERN METALS

**128:** Duraloy N, 129; Durco Ni-  
rosta, 130; Durimet, 131; Duriron,  
132; Duro Gloss C 2, 133; Duro  
Gloss, C 3, 134; Elcomet K, 135;  
Everdur, 28; G-60, 29; Genuine  
Wrought Iron, 9; Hardware Bronze,  
30; Hastelloy A, 158; Hastelloy C,  
31; Stellite 12, 69; Heat Resisting  
St. 5, 159; High Brass, 33; Highgloss  
C, 160; Highgloss DD, 161; HR-5M,  
162; Hy-Glo, 163; Illum, 35; Lesco  
18-8, 164; Lesco 18-8S, 165;  
Lesco, 21-12, 166; Lesco, 25-20,  
167; Lesco H, 168; Lesco HH, 169;  
Lesco L, 170; Lesco M, 171; Mechani-  
te Metal, 174; Midvaloy 18-8,  
176; Midvaloy 25-10, 177; Midvaloy  
25-20, 178; Misco C, 184; Monel  
Metal, 37; Nevastain KA2, 187; Nick-  
el, 10; Nickel Clad Steel, 192;  
Nickel Silver 18% A, 41; Nickel  
Silver 18% B, 42; Nickel Silver  
18%, 40; Ni-Resist, 194; Nirosa  
KA2, 199; Phosphor Bronze, 48;  
Phosphor Bronze A, 49; Phosphor  
Bronze C, 50; Phosphor Bronze D,  
51; R-50, 54; Red Brass, 55; Red  
Brass 85%, 56; Regular SS, 210;  
Rezistal 3, 211; Rezistal 4, 212;  
Rezistal 7, 213; Rezistal 2C, 215;  
Rezistal KA2, 216; Rezistal KA2  
Mo, 217; Sivyer 60, 218; Stainless  
Iron, 226; Stainless Steel, 234;  
Stellite 1, 58; Stellite 6, 59; Sterling  
Nirosta, 236; Sterling Stainless  
St. FC, 237; Super Nickel, 61;  
Sweetaloy 17, 239; Tantalum, 11;  
Taurex Bronze, 62; Tophet A, 63;  
Tophet C, 248; USS 12, 249; USS  
17, 250; USS 18-8, 251; USS 18-8  
Stabilized, 252; USS 27, 253; USS  
25-12, 254.

**ALUMINUM CHLORIDE:** Alcumite,  
15; Allegheny Metal, 69; Aluminum  
Bronze, 18; Ambrac A, 19; Bar-  
berite, 22; Deoxidized Copper, 4;  
Durco Nirosa, 130; Durimet, 131;  
Duriron, 132; Duro Gloss C 2, 133;  
Duro Gloss C3, 134; Everdur, 28;  
Fahrite N2, 152; G-60, 29; Hastelloy  
A, 158; Hastelloy C, 31; Illum, 35;  
Mechanite Metal, 174; Midvaloy 18-  
8, 176; Midvaloy 25-10, 177; Mid-  
valoy 25-20, 178; Midvaloy 30-30,  
180; Misco C, 184; Monel Metal,  
37; Nickel, 10; Nickel Clad Steel,  
192; Nickel Silver 18% A, 41; Nickel  
Silver 18% B, 42; Ni-Resist,  
194; Phosphor Bronze A, 49; Phos-  
phor Bronze C, 50; Phosphor Bronze  
D, 51; P-M-G Metal, 52; Red Brass  
85%, 56; Resistac, 57; Rezistal  
KA2 Mo, 217; Super Nickel, 61;  
Sweetaloy 17, 239; Tantalum, 11;  
Tophet A, 63.

**ALUMINUM SULPHATE:** Admiralty,  
12; Alcumite, 15; Allegheny  
44, 66; Allegheny 55, 67; Alle-  
gheny 66, 68; Allegheny Metal, 69;  
Aluminum Bronze, 18; Ambrac A,  
19; Antimonial Lead, 90; Barberite,  
22; Chemical Lead, 3; Circle L 11,  
100; Circle L 14, 163; Circle L 15,  
104; Circle L 22, 166; Circle L 23,  
107; Circle L 31, 169; Davis Metal,  
34; Deoxidized Copper, 4 & 6;  
Durco Nirosa, 130; Durimet, 131;  
Duriron, 132; Duro Gloss C 2, 133;  
Duro Gloss C3, 134; Everdur, 28;  
Fahrite N2, 152; G-60, 29; Hard-  
ware Bronze, 30; Hastelloy A, 158;  
Hastelloy C, 31; Heat Resisting St.  
5, 159; Highgloss C, 160; Highgloss  
DD, 161; Illum, 35; Lesco 18-8,  
164; Lesco 18-8S, 165; Lesco  
21-12, 166; Lesco 25-20, 167;  
Lesco H, 168; Lesco HH, 169;  
Lesco L, 170; Lesco M, 171; Mechani-  
te Metal, 174; Midvaloy 18-8,  
176; Midvaloy 25-10, 177; Midvaloy  
25-20, 178; Midvaloy 30-30,  
180; Misco C, 184; Monel Metal,  
37; Nevastain KA2, 187; Nickel,  
10; Nickel Clad Steel, 192; Nickel  
Silver 18% A, 41; Nickel Silver 18% B,  
42; Ni-Resist, 194; Nirosa KA2,  
199; Phosphor Bronze A, 49; Phos-  
phor Bronze C, 50; Phosphor Bronze  
D, 51; Red Brass, 55; Red Brass 85%,  
56; Regular SS, 210; Rezistal 3, 211;  
Rezistal 4, 212; Rezistal 7, 213;  
Rezistal 2C, 215; Rezistal KA2, 216;  
Rezistal KA2 Mo, 217; Rezistal  
2600, 214; Sivyer 60, 218; Sivyer  
66, 220; Stainless Iron, 226; Stain-  
less Iron 12, 228; Stainless Iron 16,  
229; Stainless Iron 18, 230; Stain-  
less Iron 24, 231; Stainless Iron 2  
F. M., 227; Stainless Steel, 234;  
Sterling Nirosta, 236; Sterling Stain-  
less St. F. C., 237; Super Nickel,  
61; Sweetaloy 17, 239; Tantalum,  
11; Tophet A, 63; Tophet C, 248;  
USS 12, 249; USS 17, 250; USS 18-  
8, 251; USS 18-8 Stabilized, 252;  
USS 25-12, 253; USS 27, 254.

**AMMONIUM CHLORIDE:** Admiralty,  
12; Alcumite, 15; Allegheny  
33, 65; Allegheny 44, 66; Allegheny  
55, 67; Allegheny 66, 68; Allegheny  
Metal, 69; Bethadur 2, 71; Chrom-  
ium Iron, 93; Defheat, 123;  
Defrust, Spec., 125; Defstain,  
126; Dioxidized Copper, 4; Durco  
Nirosa, 130; Durimet, 131; Duriron,  
132; Duro Gloss C2, 133; Duro  
Gloss C3, 134; Elcomet K, 135;  
Everdur, 28; Fahrite N2, 152; G-  
60, 29; Hardware Bronze, 30;  
Hastelloy A, 158; Hastelloy C, 31;  
Heat Resisting St. 5, 159; High  
Brass, 33; Highgloss C, 160; High-  
gloss DD, 161; HR-5M, 162; Illum,  
35; Mechanite Metal, 174; Misco C,  
184; Monel Metal, 37; Nickel, 10; Nickel  
Clad Steel, 192; Nickel Silver 18%  
A, 41; Nickel Silver 18% B, 42;  
Nickel Silver 18%, 40; Ni-  
rosa KA2, 199; Phosphor Bronze, 48;  
Phosphor Bronze A, 49; Phosphor  
Bronze C, 50; Phosphor Bronze D,  
51; Red Brass, 55; Red Brass 85%,  
56; Rezistal 2C, 215; Rezistal 3,  
211; Rezistal 4, 212; Rezistal 7,  
213; Rezistal KA2, 216; Rezistal  
KA2 Mo, 217; R-50, 54; Sivyer  
60, 218; Sterling Nirosta, 236; Stain-  
less St. F. C., 237; Super Nickel,  
61; Sweetaloy 17, 239; Tantalum,  
11; Tophet A, 63; Tophet C, 248;  
USS 12, 249; USS 17, 250; USS  
18-8, 251; USS 18-8 Stabilized,  
252; USS 25-12, 253; USS 27, 254.

**AMMONIUM CHLORIDE:** Admiralty,  
12; Alcumite, 15; Allegheny  
33, 65; Allegheny 44, 66; Allegheny  
55, 67; Allegheny 66, 68; Allegheny  
Metal, 69; Bethadur 2, 71; Chrom-  
ium Iron, 93; Defheat, 123;  
Defrust, Spec., 125; Defstain,  
126; Dioxidized Copper, 4; Durco  
Nirosa, 130; Durimet, 131; Duriron,  
132; Duro Gloss C2, 133; Duro  
Gloss C3, 134; Elcomet K, 135;  
Everdur, 28; Fahrite N2, 152; G-  
60, 29; Hardware Bronze, 30;  
Hastelloy A, 158; Hastelloy C, 31;  
Heat Resisting St. 5, 159; High  
Brass, 33; Highgloss C, 160; High-  
gloss DD, 161; HR-5M, 162; Illum,  
35; Mechanite Metal, 174; Misco C,  
184; Monel Metal, 37; Nevastain  
KA2, 187; Nickel, 10; Nickel Clad  
Steel, 192; Nickel Silver 18% A, 41;  
Nickel Silver 18% B, 42; Nickel Silver  
18%, 40; Ni-  
rosa KA2, 199; Phosphor Bronze, 48;  
Phosphor Bronze A, 49; Phosphor  
Bronze C, 50; Phosphor Bronze D,  
51; Red Brass, 55; Red Brass 85%,  
56; Super Nickel, 61; Sweetaloy 17,  
239; Tantalum, 11; Taurex Bronze,  
62; Tophet A, 63.

**ANILINE:** Aluminum 28, 1; Al-  
clad, 14; Aluminum 38, 17; Davis  
Metal, 24; Duraloy A, 127; Duraloy  
B, 128; Duriron 132; Elcomet-K,  
135; Empire 30, 140; G-60, 29;  
Sterling Nirosta, 236; Sterling Stain-  
less St. F. C., 237; Sweetaloy 17,  
239; Tantalum, 11; Tophet A, 63;  
Tophet C, 248; USS 12, 249; USS  
17, 250; USS 18-8, 251; USS  
18-8 Stabilized, 252; USS 25-12,  
253; USS 27, 254; 100 Alloy, 258.

**AMMONIUM HYDROXIDE:** Alle-  
gheny 33, 65; Allegheny 44, 66;  
Allegheny 55, 67; Allegheny 66, 68;  
Allegheny Metal, 69; Aluminum 28,  
1; Alclad, 14; Aluminum 38, 17;  
Antimonial Lead, 20; Bethadur 1,  
70; Bethadur 2, 71; Bethadur 4,  
72; Rezistal 3, 211; Rezistal 4,  
212; Rezistal 7, 213; Rezistal 2C,  
215; Rezistal KA2, 216; Rezistal  
KA2 Mo, 217; Sivyer 60, 218; Stain-  
less Iron, 226; Stainless Steel, 234;  
Super Nickel, 61; Sterling Nirosta,  
236; Sweetaloy 17, 239; Tantalum,  
11; Taurex Bronze, 62; Tophet A,  
63; Tophet C, 248; USS 12, 249;  
USS 17, 250; USS 18-8, 251; USS  
18-8 Stabilized, 252; USS 25-12,  
253; USS 27, 254; 100 Alloy, 258.

**AMMONIUM SULPHATE:** Admiralty,  
12; Alcumite, 15; Allegheny  
33, 65; Allegheny 44, 66; Allegheny  
55, 67; Allegheny 66, 68; Allegheny  
Metal, 69; Aluminum 28, 1; Alclad,  
14; Aluminum 38, 17; Antimo-  
nial Lead, 20; Barberite, 22; Bethadur 2,  
71; Chemical Lead, 3; Circle L 22,  
102; Circle L 14, 103; Circle L 15,  
104; Circle L 22, 106; Circle L 23,  
107; Circle L 31, 109; Cyclops 17  
Metal, 122; Defheat, 123; Defirst,  
124; Defirst, Spec., 125; Defstain,  
126; Duraloy B, 128; Duraloy N,  
129; Durco Nirosa, 130; Durimet,  
131; Duriron, 132; Duro Gloss C  
2, 133; Duro Gloss C 3, 134; El-  
comet-K, 135; Empire 30, 140;  
Fahrite N2, 152; Fine Silver, 7;  
G-60, 29; Genuine Wrought Iron,  
8 and 9; Hastelloy A, 158; Hastel-  
loy C, 31; Heat Resisting St. 5,  
159; Highgloss C, 160; Highgloss  
DD, 161; Hy-Glo, 163; Illum, 35; Lesco  
18-8, 164; Lesco 21-12, 166; Lesco  
25-20, 167; Lesco H, 168; Lesco  
HH, 169; Lesco L, 170; Lesco M,  
171; Mechanite Metal, 174; Mid-  
valoy 13-00, 175; Midvaloy 18-8,  
176; Midvaloy 25-10, 177; Midvaloy  
25-20, 178; Midvaloy 30-30,  
180; Midvaloy 26-02, 179; Midvaloy  
30-30, 180; Monel Metal, 32; Phos-  
phor Bronze, 48; Premier Nickel  
Chrome, 203; R-50, 54; Rezistal  
3, 211; Rezistal 4, 212; Rezistal 7,  
213; Rezistal 2C, 215; Rezistal KA2,  
216; Rezistal KA2 Mo, 217; Rezistal  
2600, 214; Sivyer 60, 218; Sivyer  
66, 220; Stainless Iron, 226; Stain-  
less Iron 12, 228; Stainless Iron 16,  
229; Stainless Iron 18, 230; Stain-  
less Iron 24, 231; Stainless Iron 2  
F. M., 227; Stainless Steel, 234;  
Sterling Nirosta, 236; Sterling Stain-  
less St. F. C., 237; Super Nickel,  
61; Sweetaloy 17, 239; Tantalum,  
11; Taurex Bronze, 62; Tophet A,  
63; Tophet C, 248; USS 12, 249;  
USS 17, 250; USS 18-8, 251; USS  
18-8 Stabilized, 252; USS 25-12,  
253; USS 27, 254.

**AMYL ACETATE:** Admiralty, 12;  
Aluminum 28, 1; Alclad, 14; Alum-  
inum 38, 17; Aluminum Bronze,  
18; Ambrac A, 19; Chromium Iron,  
93; Deoxidized Copper, 4; Duriron,  
132; Duro Gloss C2, 133; Duro  
Gloss C3, 134; Elcomet K, 135;  
Everdur, 28; Fahrite N2, 152; G-  
60, 29; Hardware Bronze, 30;  
Hastelloy A, 158; Hastelloy C, 31;  
Heat Resisting St. 5, 159; Highgloss  
C, 160; Highgloss DD, 161; Illum,  
35; Mechanite Metal, 174; Misco C,  
184; Monel Metal, 37; Nickel, 10; Nickel  
Silver 18% A, 41; Nickel Silver 18% B,  
42; Nickel Silver 18%, 40; Ni-  
rosa KA2, 199; Phosphor Bronze, 48;  
Phosphor Bronze A, 49; Phosphor  
Bronze C, 50; Phosphor Bronze D,  
51; Red Brass, 55; Red Brass 85%,  
56; Rezistal 2C, 215; Rezistal 3,  
211; Rezistal 4, 212; Rezistal 7,  
213; Rezistal KA2, 216; Rezistal  
KA2 Mo, 217; R-50, 54; Sivyer  
60, 218; Sterling Nirosta, 236; Stain-  
less St. F. C., 237; Super Nickel,  
61; Sweetaloy 17, 239; Tantalum,  
11; Taurex Bronze, 62; Tophet A,  
63; Tophet C, 248; USS 12, 249;  
USS 17, 250; USS 18-8, 251; USS  
18-8 Stabilized, 252; USS 25-12,  
253; USS 27, 254.

**AMYL CHLORATE:** Admiralty, 12;  
Alcumite, 15; Allegheny 33, 65;  
Allegheny 44, 66; Allegheny 55, 67;  
Allegheny 66, 68; Allegheny Metal,  
69; Aluminum 28, 1; Alclad, 14;  
Alumina 38, 17; Aluminum Bronze,  
18; Ambrac A, 19; Chromium Iron,  
93; Deoxidized Copper, 4; Duriron,  
132; Duro Gloss C2, 133; Duro  
Gloss C3, 134; Elcomet K, 135;  
Everdur, 28; Fahrite N2, 152; G-  
60, 29; Hardware Bronze, 30;  
Hastelloy A, 158; Hastelloy C, 31;  
Heat Resisting St. 5, 159; Highgloss  
C, 160; Highgloss DD, 161; Illum,  
35; Mechanite Metal, 174; Misco C,  
184; Monel Metal, 37; Nickel, 10; Nickel  
Silver 18% A, 41; Nickel Silver 18% B,  
42; Nickel Silver 18%, 40; Ni-  
rosa KA2, 199; Phosphor Bronze, 48;  
Phosphor Bronze A, 49; Phosphor  
Bronze C, 50; Phosphor Bronze D,  
51; Red Brass, 55; Red Brass 85%,  
56; Rezistal 2C, 215; Rezistal 3,  
211; Rezistal 4, 212; Rezistal 7,  
213; Rezistal KA2, 216; Rezistal  
KA2 Mo, 217; R-50, 54; Sivyer  
60, 218; Sterling Nirosta, 236; Stain-  
less St. F. C., 237; Super Nickel,  
61; Sweetaloy 17, 239; Tantalum,  
11; Taurex Bronze, 62; Tophet A,  
63; Tophet C, 248; USS 12, 249;  
USS 17, 250; USS 18-8, 251; USS  
18-8 Stabilized, 252; USS 25-12,  
253; USS 27, 254.

**AMYL CHLORIDE:** Admiralty, 12;  
Alcumite, 15; Allegheny 33, 65;  
Allegheny 44, 66; Allegheny 55, 67;  
Allegheny 66, 68; Allegheny Metal,  
69; Aluminum 28, 1; Alclad, 14;  
Alumina 38, 17; Aluminum Bronze,  
18; Ambrac A, 19; High Brass, 33;  
Deoxidized Copper, 4; Duriron, 132;  
Duro Gloss C2, 133; Duro Gloss C3,  
134; Elcomet K, 135; Everdur, 28;  
Fahrite N2, 152; G-60, 29; Hardware  
Bronze, 30; Hastelloy A, 158; Hastel-  
loy C, 31; Heat Resisting St. 5, 159;  
High Brass, 33; Highgloss C, 160; High-  
gloss DD, 161; HR-5M, 162; Illum, 35;  
Mechanite Metal, 174; Misco C, 184;  
Monel Metal, 37; Nickel, 10; Nickel  
Silver 18% A, 41; Nickel Silver 18% B,  
42; Nickel Silver 18%, 40; Ni-  
rosa KA2, 199; Phosphor Bronze, 48;  
Phosphor Bronze A, 49; Phosphor  
Bronze C, 50; Phosphor Bronze D,  
51; Red Brass, 55; Red Brass 85%,  
56; Super Nickel, 61; Sweetaloy 17,  
239; Tantalum, 11; Taurex Bronze,  
62; Tophet A, 63.

## MODERN METALS

**BENZALDEHYDE:** Allegheny 33, 65; Aluminum Bronze, 18; Ambrac, A, 19; Defistain, 126; Deoxidized Copper, 4; Duro Gloss C<sup>2</sup>, 133; Duro Gloss C, 134; Elcomet-K, 135; Empire 30, 140; Everdur, 28; Fahrile, N<sup>2</sup>, 152; G-60, 29; Hastelloy C, 31; Heat Resisting St. 5, 159; Higloss C, 160; Higloss DD, 161; HR-5M, 162; Illium, 35; Monel Metal, 37; Nickel 10; Nickel Clad Steel, 192; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 31; R-50, 54; Red Brass 85%, 56; Super Nickel, 61; Tantalum, 11; Tophet A, 63; Tophet C, 248; USS 12, 249; USS 17, 250; USS USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

**BROMINE:** Aluminum Bronze, **18**; Ambrac A, **19**; Deoxidized Copper, **1**; Everdur, **28**; Hastelloy C, **31**; HR-**1**, **162**; Nickel Silver, **18**% B, **42**; Nickel-C, **11**; Nickel Silver, **18**% B, **42**; Phosphor Bronze A, **49**; Phosphor Bronze C, **50**; Phosphor Bronze D, **51**; Red Brass, **85**%, **56**; Super Nickel, **61**; Tantanium, **11**; Tantitron, **245**; Tophet A, **63**; USS 18-8, **251**; USS 18-8 Stabilized, **252**; USS 25-12, **253**.

**BUTYL ACETATE:** Admiralty, 12; Aluminum 28, 1; Aleclad, 14; Aluminum 38, 17; Ambrac A, 19; Deoxidized Copper, 4; Duriron, 132; Duro Gloss C3, 134; Elecomet-K, 135; Everdur, 28; Fahrline N2, 152; G-60, 29; Hardware Bronze, 30; Hastelloy C, 31; Heat Resisting St. 5, 159; High Brass, 33; Hi-gloss C, 160; Hi-gloss DD, 161; HR-5M, 162; Illum, 33; Monel Metal, 37; Nickel, 10; Nickel Clad Steel, 192; Nickel Silver 18%, 40; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Phosphor Bronze, 48; R-50, 51; Red Brass, 55; Sterling Nirossta, 236; Sterling Stainless St. FC, 237; Super Nickel, 61; Sweetaloy 17, 239; Tantalum 11; Taurex Bronze, 62; Tophet A, 63; Tophet C, 248; USS 12, 249; USS 17, 250; USS 18-S, 251; USS 18-S Stabilized, 252; USS 25-12, 253; USS 27, 254.

**CALCIUM CHLORIDE:** Admiralty, 12; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 25, 1; Alclad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Anti-monial Lead, 20; Barberite, 22; Bethadur 1, 70; Bethadur 2, 71; Bethadur 4, 72; Bethalon, 76; Chemical Lead, 3; Chromax, 89; Circle L 11, 100; Circle L 12, 101; Circle L 13, 102; Circle L 14, 103; Circle L 15, 104; Circle L 22, 106; Circle L 23, 107; Circle L 31, 109; Davis Metal, 24; Defheat, 123; Defrust, 124; Defrust Spec., 125; Defstain, 126; Deoxidized Copper 4 & 5; Durco Nirosita, 130; Durimet, 131; Duriron, 132; Duro Gloss C<sub>2</sub>, 133; Duro Gloss C<sub>3</sub>, 134; Elcomet, K, 135; Everdur, 28; Everbrite, 27; Fahrte N<sub>2</sub>, 152; G-60, 29; Genuine Wrought Iron, 8; Hardware Bronze, 30; Hastelloy A, 158; Hastelloy C, 31; Heat Resisting St. 5, 159; High Brass, 33; Higloss C, 160; Higloss DD, 161; HR-5M, 162; Hy-Glo, 163; Illium, 35; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Lesco 18-8, 164; Lesco 18-S 8, 165; Lesco 21-12, 166; Lesco 25-20, 167; Meehanite Metal, 174; Midvaloy 13-00, 175; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 30-30, 180; Midvaloy 26-02, 179; Misco C, 184; Monel Metal, 37; Nichrome, 190; Nichrome IV, 39; Nickel, 10; Nickel Clad Steel, 192; Nickel Silver 18%, 40; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Ni-Resist, 194; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G, Metal 32; R-50, 54; Red Brass, 55; Red Brass 85%, 56.

Regular SS, **210**; Resistal 4, **212**; Resistal 7, **213**; Resistal 2C, **215**; Resistal KA2, **216**; Resistal KA2 Mo, **217**; Stainless Iron, **220**; Stainless Steel, **234**; Sterling Nirosia, **236**; Sterling Stainless Steel, **237**; Super Nickel, **61**; Sweetaloy 17, **239**; Silver, **60**, **218**; Tantalum, **11**; Tantrex Bronze, **62**; Tophet A, **63**; USS 18-8 **251**; USS 18-8 Stabilized, **252**; USS **25-12**, **253**, **300**.

**CALCIUM HYPOCHLORITE:** Ambrac A, **19**; Alumcite, **15**; Aluminum Bronze, **18**; Chromium Iron, **93**; Davis Métal, **24**; Defstain, **126**; Deoxidized Copper, **4**; Durimet, **131**; Duriron, **132**; Duro Gloss C2, **133**; Duro Gloss C3, **134**; Everdur, **28**; Fahrte N2, **152**; Hastelloy C, **31**; Heat Resisting St, **5**, **59**; Higloss C, **160**; Higloss DD, **161**; HR-5M, **162**; Illium, **35**; Meehanite Metal, **174**; Midvaloy 18-8, **176**; Midvaloy 25-10, **177**; Midvaloy 25-20, **178**; Midvaloy 1835A, **181**; Midvaloy 26-02, **179**; Midvaloy 30-30, **180**; Monel Metal, **37**; Nickel **10**; Nickel Clad Steel, **192**; Nickel Silver 18% A, **41**; Nickel Silver 18% B, **42**; Ni-Resist, **194**; Nirostro KA2, **199**; Phosphor Bronze A, **40**; Phosphor Bronze C, **50**; Phosphor Bronze D,

51: Red Brass, 85-<sup>1</sup>/<sub>2</sub>, 56; Resistac,  
 57; Resistal 3, 211; Resistal 4,  
 212; Resistal 7, 213; Resistal 2C  
 213; Resistal KA2 Mo, 217; Standard  
 Misco, 235; Super Nickel, 61.  
 Tantalum, 11; Tuft-Stuf, 64; USS  
 17, 250; USS 18-8, 251; USS 18-8  
 Stabilized, 252; USS 25-12, 253;  
 US 27, 254.

**CARBON BISULPHIDE:** Aluminum 38,  
 28; Alclad, 14; Aluminum 38,  
 17; Chromium Iron, 93; Defiheat,  
 123; Defirust, 124; Defirust Spec.,  
 125; Defistain, 126; Duraloy N,  
 129; Duriron, 132; G-60, 29; Has-  
 telloy C, 31; HR-5M, 162; Hy-Glo,  
 163; Illium, 35; Meehanite Metal,  
 174; Midvaloy 13-00, 175; Midva-  
 lov 18-8, 176; Midvaloy 26-02, 179;  
 Misco C, 184; Monel Metal, 37;  
 Nickel, 10; Nickel Clad Steel, 192;  
 Nirosita KA2, 199; R-50, 51; Regu-  
 lar SS, 210; Resistal 3, 211; Resistal  
 4, 212; Resistal 7, 213; Resistal  
 2C, 215; Resistal KA2, 216; Resi-  
 tal KA2 Mo, 217; Sterling Nirosita  
 236; Sterling Stainless St. FC, 237;  
 Sweetaloy 17, 239; Tantalum, 11;  
 Tophet A, 63; Tophet C, 248; USS  
 12, 249; USS 18-8, 251; USS 18-8,  
 Stabilized, 252; USS 25-12, 253.

**CARBON TETRACHLORIDE:** Admiralty, 12; Alcumite, 15; Aluminum, 28, 1; Alclad, 14; Aluminum 3S, 17; Aluminum Bronze, 18; Ambrac A, 19; Barberite, 22; Circle C 22, 106; Circle L 23, 107; Circle L 31, 109; Davis Metal, 24; Deoxidized Copper, 4 and 5; Defi-heat, 123; Defirust, 124; Defirust, Spec., 125; Defistain, 126; Dow-metal, 25; Durco Nirosta, 130; Durimel, 131; Duriron, 132; Duro-Gloss C<sub>2</sub>, 120; Duro Gloss C<sub>3</sub>, 134; Everdur, 28; G-60, 29; Genuine

Wrought Iron, 8 & 9; Hardware  
 Bronze, 30; Hastelloy C, 31; Heat  
 Resisting St. 5, 159; Higloss C,  
**160**; Higloss DD, **161**; HR-5M, **162**  
 Hy-Glo, **163**; Ilium, 35; Lesco 18-  
 8, **164**; Lesco 18-8 S, **165**; Lesco  
 21-12, **166**; Lesco 25-20, **167**;  
 Lesco H, **168**; Lesco HH, **169**;  
 Lesco L, **170**; Lesco M, **171**; Mee-  
 hanite Metal, **174**; Midvaloy 13-00,  
 175; Midvaloy 18-8, **176**; Midvaloy  
 25-10, **177**; Midvaloy 25-20, **178**;  
 Midvaloy 26-02, **179**; Midvaloy 30-  
**30**, **180**; Misco C, **184**; Monel Metal,  
 37; Nickel, **10**; Nickel Clad Steel,  
**192**; Nickel Silver 18%, **40**; Nickel  
 Silver 18% A, **41**; Nickel Silver  
 18% B, **42**; Ni-Resist, **194**; Nirosta  
 KA2, **199**; Omega Nickel Silver  
 18%, A, **43**; Omega Nickel Silver

A. 45; Omega Nickel Silver 18% B. 44; Omega Phos. Bronze 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; Phosphor Bronze, 48; Phosphor Bronze A. 49; Phosphor Bronze C. 50; Phosphor Bronze D. 51; P-M. G. Metal, 52; Red Brass, 53; Red Brass 85% 56; Regular SS, 210; Resistac, 57; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2C, 215; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron 16, 229; Stainless Iron 18, 230; Stainless Iron 24, 231; Sterling Nirosita, 236; Sterling Stainless St. FC, 237; Super Nickel, 61; Sweet-aloy 17, 239; Tantalum, 11; Taurex Bronze, 62; Tophet A. 63; Tophet C. 24; 100 Alloys 258.

**CARBONIC ACID:** Allegheny 33.  
55; Allegheny 44, 66; Allegheny,  
55, 67; Allegheny 66, 68; Allegheny  
Metal, 69; Aluminum 28, 1; Alclad,  
14; Aluminum 38, 17; Aluminum  
Bronze, 18; Ambrac A, 19; Chrom-  
ium Iron, 93; Circle L 11, 100.

Circle L **14**, **103**; Circle L **15**, **104**  
 Circle L **22**, **106**; Circle L **23**, **107**  
 Circle L **31**, **109**; Davis Metal, **24**  
 Defibheat, **123**; Defirust, **124**; Defirust,  
 Spec., **125**; Definstain, **126**  
 Deoxidized Copper, **4**; Duraloy N,  
**129**; Durco Nirosita, **130**; Durimet,  
**131**; Duriron, **132**; Duro Gloss C3,  
**134**; Elcomet-K, **135**; Everdur, **28**  
 Fahrte N<sup>2</sup>, **152**; G-60, **29**; Hastelloy A, **158**; Hastelloy C, **31**; Heat  
 Resisting St. 5, **159**; Highloss C, **160**;  
 Highloss DD, **161**; HR-5M, **162**; Hy-Glo, **163**; Iium, **35**; Lesco 18-8,  
**164**; Lesco 18-8S, **165**; Lesco 21-  
**12**, **166**; Lesco 25-20, **167**; Lesco H,  
**168**; Lesco HH, **169**; Lesco L,  
**170**; Lesco M, **171**; Mechanite  
 Metal, **174**; Midvaloy 13-00, **175**;  
 Midvaloy 18-8, **176**; Midvaloy 25-  
 10, **177**; Midvaloy 25-20, **178**; Mid-  
 valoy 1835A, **181**; Midvaloy 26-02,  
**180**; Misco C, **184**; Monel Metal,  
**37**; Nevastain KA2, **187**; Nevastain RA,  
**188**; Nickel, **10**; Nickel Clad  
 Steel, **192**; Nickel Silver 18% A,  
**11**; Nickel Silver 18% B, **42**; Ni-  
 Resist, **194**; Nirosita KA2, **199**;  
 Phosphor Bronze A, **49**; Phosphor Bronze D,  
**51**; Red Brass 85%, **56**; Regular  
 SS, **210**; Rezistal 3, **211**; Rezistal  
 4, **212**; Rezistal 7, **213**; Rezistal 2C,  
**215**; Rezistal KA2, **216**; Rezistal  
 KA2 Mo, **217**; R-50, **34**; Sterling  
 Nirosita, **236**; Sterling Stainless St.  
 FC, **237**; Super Nickel, **61**; Sweet-  
 aloy 17, **239**; Tantalum, **11**; Tophet  
 A, **63**; Tophet C, **248**; USS 12,  
**249**; USS 17, **250**; USS 18-8, **251**;  
 USS 18-8 stabilized, **252**; USS 25-  
**12**, **253**; USS 27, **254**.

**CHLORACETIC ACID:** **Hastelloy C**, **31; HR-5M, 162;** **Illum, 35;** **Nickel 10;** **Nickel Clad Steel, 192;** **Monel Metal, 37;** **Phosphor Bronze D, 51;** **Stellite 1, 58;** **Stellite 6, 59;** **Stellite 12, 60;** **Tantalum, 11.**

**CHLORINE WATER:** **Admiralty, 12;** **Aluminum Bronze, 18;** **Ambrae A, 19;** **Antimonial Lead, 20;** **Chemical Lead, 3;** **Davies Metal, 24;** **Deoxidized Copper, 4 & 5;** **Duriron, 132;** **Everdur, 28;** **Hardware Bronze, 30;** **Hastelloy C, 31; HR-5M, 162;** **Middlesex, 18 & 172;** **Micarta, 25, 30,**

**valoy** 18-8, **176**: Midvaloy 25-10, 177; Midvaloy 25-20, **178**; Milvaloy 30-30, **180**; Nevastain RA, **188**; Nickel Silver 18% A, **41**; Nickel Silver 18% B, **42**; Nickel Silver 18%, **40**; Phosphor Bronze, **48**; Phosphor Bronze C, **50**; Phosphor Bronze Bronze D, **51**; Red Brass, **55**; Red Brass 85%, **56**; Super Nickel, **61**; Tantalum, **11**; Taurex Bronze, **62**.

**CHROMIC ACID:** Aluminum 28, **1**; Alclad, **14**; Aluminum 38, **17**; Chromium Iron, **93**; Defiheat, **123**; Defirstir, **124**; Defirstir Spec, **125**; Defistain, **126**; Downmetal, **25**; Duriron, **132**; Fahrite N<sup>o</sup>, **152**; G-60, **39**; Genuine Wrought Iron, **8**; Hasstelloy C, **31**; HR-5M, **162**; Irium, **35**; Mechanite Metal, **174**; Midvaloy 18-8, **176**; Midvaloy 25-10, **177**; Midvaloy 25-20, **178**; Midvaloy 26-02, **179**; Midvaloy 30-30, **180**; Nevastain KA2, **187**; Nirossta KA2, **199**; R-50, **54**; Rezistal 2C, **215**.

Rezistal 3, 211; Rezistal 4, 212;  
 Rezistal 7, 213; Rezistal KA2, 216;  
 Rezistal KA2 Mo, 217; Tantalum,  
 11; USS 12, 249; USS 17, 250;  
 USS 18-8, 251; USS 18-8 Stabilized,  
 252; USS 25-12, 253; USS 27, 254.  
**CITRIC ACID:** Admiralty, 12; Al-  
 legheny 33, 65; Allegheny 44, 66;  
 Allegheny 55, 67; Allegheny 66, 68;  
 Allegheny Metal, 69; Aluminum, 2S,  
 1; Alclad, 14; Aluminum 3S, 17;  
 Aluminum Bronze, 18; Ambrac A,  
 19; Barberite, 22; Bethadur 2, 71;  
 Chromax, 89; Chromium Iron, 93;  
 Circle L 11, 100; Circle L 14, 103;  
 Circle L 15, 104; Circle L 22, 106;  
 Circle L 23, 107; Circle L 31, 109;  
 Davis Metal, 24; Defheat, 123;  
 Defrust, 124; Defrust Spec., 125;  
 Defstain, 126; Deoxidized Copper  
 4 & 5; Duraloy A, 127; Duraloy B,  
 128; Duraloy N, 129; Durco Nirosa  
 130; Durimet, 131; Duriron, 132;  
 Duro Gloss C 2, 133; Duro Gloss C  
 3, 134; Elecomet-K, 135; Empire  
 30, 140; Everbrite, 27; Everdur,  
 28; Fahrts N2, 152; Fine Silver,  
 7; G-60, 29; Hardware Bronze, 30;  
 Hastelloy A, 158; Hastelloy C, 31;  
 Heat Resisting St. 3, 159; High  
 Brass, 33; Higloss C, 160; Higloss

Illum, **35**; Lesco **18-8**, **161**; Lesco 18-8 S, **165**; Lesco **21-12**, **166**; Lesco **25-20**, **167**; Lesco **H**, **168**; Lesco **HH**, **169**; Lesco **L**, **170**; Lesco **M**, **171**; Mechanite Metal, **174**; Midvaloy **18-8**, **176**; Midvaloy **25-10**, **177**; Midvaloy **25-20**, **178**; Midvaloy **26-02**, **179**; Midvaloy **30-30**, **180**; Misco C, **184**; Monel Metal, **185**; Nevastain KA<sub>2</sub>, **187**; Nevastain RA, **188**; Nichrome, **190**; Nichrome IV, **39**; Nickel, **10**; Nickel Clad Steel, **192**; Nickel Silver, **18** % A, **41**; Nickel Silver **18%**, **B**, **42**; Nickel Silver, **18%**, **40**; Ni-Resist, **191**; Nirosita KA<sub>2</sub>, **199**; Omega Nickel Silver **18** % A, **43**; Omega Nickel Silver **18** % B, **44**; Omega Phos, Bronze **30**, **45**; Omega Phos, Bronze **47**, **46**; Omega Phos, Bronze **209**, **47**; Phosphor Bronze, **48**; Phosphor Bronze A, **49**; Phosphor Bronze C, **50**; Phosphor Bronze D, **51**; R-50, **54**; Red Brass, **55**; Red Brass 85%, **56**; Regular SS, **210**; Rezistal 3, **211**; Rezistal 4, **212**; Rezistal 7, **213**; Rezistal 2C, **215**; Rezistal KA<sub>2</sub>, **216**; Rezistal KA<sub>2</sub> Mo, **217**; Sivyer 60, **218**; Stainless Iron, **226**; Stainless Steel, **234**; Sterling Nirosita, **236**; Sterling Stainless St, FC, **237**; Stellite 1, **38**; Stellite 6, **39**; Stellite 12, **60**; Super Nickel, **61**; Sweetaloy 17, **239**; Tantalum, **11**; Tairex Bronze, **62**; Tophet A, **63**; Tophet C, **248**; USS **18-8**, **251**; USS **18-8** Stabilized, **253**; USS **25-12**, **253**.

**COPPER SULPHATE:** Admiralty, 12; Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum Bronze, 18; Ambrac A, 19; Barberite, 22; Bethadur 2, 71; Bethadur 6, 73; Bethadur 8, 74; Chromium Iron, 93; Circle L 1<sup>2</sup>, 101; Circle L 2<sup>2</sup>, 106; Circle L 23, 107; Circle L 31, 109; De-oxidized Copper, 4 & 5; Duraloy A, 127; Durco Nirosita, 130; Durimet, 131; Duriron, 132; Duro Gloss C, 133; Duro Gloss C3, 134; Empire 30, 140; Everdur, 23; Fahre N<sup>o</sup> 2, 152; G-60, 29; Hardware Bronze, 30; Hastellox C, 31; Heat Resisting St. 5, 159; High Brass, 33; Highgloss C, 160; High Gloss DD, 161; HR-5M, 162; Hi-Glo, 163; Ilum, 35; Lesco H, 168; Lesco L, 169; Lesco L, 170; Lesco M, 171; Lesco 18-8, 164; Lesco 18-8-S, 165; Lesco 21-12, 166; Lesco 25-20, 167; Midvaloy 13-00, 175; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 26-02, 179; Nevestain KA, 187; Nevestain RA, 188; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Nirosita KA, 199; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P. M. G. Metal, 52; Reed Brass, 55; Red Brass 85%, 56; Regular SS, 210; Rezistal 2C, 215; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal KA, 216; Rezistal KA2 Mo, 217; Sivyer 60, 218; Stainless Iron, 226; Stainless Steel, 234; Sterling Nirosita, 236; Sterling Stainless St, FC, 237; Stellite 1, 338; Stellite 6, 59; Stellite 12, 60; Stinner Nickel 61; Sweetaloy 17, 239; Tantalum, 11; Tanturon 20; Taurex Bronze, 62; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized 252; USS 27, 254; USS 32, 255; USS 34, 255;

## MODERN METALS

Stabilized, 252; USS 25-12, 253; USS 27, 254.

**FATTY ACIDS:** Admiralty, 12; Alcumite, 15; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Barberite, 22; Bethadur 2, 71; Bethadur 6, 73; Bethadur 8, 74; Chemical Lead, 3; Chromium Iron, 93; Circle L 11, 100; Circle L 12, 101; Circle L 14, 103; Circle L 15, 104; Circle L 22, 106; Circle L 23, 107; Circle L 31, 109; Defheat, 123; Defrust, 124; Defrust Spec., 125; Defstain, 126; Deoxidized Copper, 4 and 5; Duraloy A, 127; Duraloy B, 128; Durco Nirosa, 130; Durimet, 131; Duriron, 132; Duro Gloss C, 133; Duro Gloss C3, 134; Elcomet K, 135; Everdur, 28; Fahrte N2, 152; G-60, 29; Hardware Bronze, 30; Hastelloy A, 138; Hastelloy C, 31; Heat Resisting St. 5, 159; High Brass, 33; Highloss C, 160; Highloss DD, 161; HR-5M, 162; Hy-Glo, 163; Illium, 35; Lesco 18-8, 164; Lesco 18-8 S, 165; Lesco 21-12, 166; Lesco 25-20, 167; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Mechanite Metal, 174; Misco C, 184; Monel Metal, 37; Nevastain KA2, 187; Nevastain RA, 188; Nickel, 10; Nickel Clad Steel, 192; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Nirosa KA2, 199; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; P-M-G Metal, 52; R-50, 54; Red Brass, 55; Red Brass 85%, 56; Regular SS, 210; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2C, 215; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Sterling Nirosta, 236; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

**FERRIC CHLORIDE:** Duriron, 132; G-60, 29; HR-5M, 162; Hastelloy C, 31; Monel Metal, 37; Nickel, 10; Nickel Clad Steel, 192; Ni-Resist, 194; Tantalum, 11; 100 Alloy, 258.

**FERRIC SULPHATE:** Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Duraloy A, 127; Duraloy B, 128; Durimet, 131; Duriron, 132; Duro Gloss C, 134; Elcomet K, 135; Empire 30, 140; Fahrte N2, 152; G-60, 29; Hastelloy C, 31; Heat Resisting St. 5, 159; Highloss C, 160; Highloss DD, 161; HR-5M, 162; Midvaloy 13-00, 175; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 26-02, 179; R-50, 54; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2C, 215; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Siver 60, 218; Sterling Nirosta, 236; Sterling Stainless St. FC, 237; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; Tophet A, 63; Tophet C, 248; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

**FERROUS CHLORIDE:** Admiralty, 12; Ambrac A, 19; Deoxidized Copper, 4 & 5; Duriron, 132; Everdur, 28; G-60, 29; Hardware Bronze, 30; Hastelloy C, 31; High Brass, 33; Lesco 18-8, 164; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Ni-Resist, 194; Phosphor Bronze A, 49; Phosphor Bronze D, 51; Phosphor Bronze, 48; Red Brass, 55; Red Brass 85%, 56; Sterling Nirosta, 236; Sterling Stainless St. FC, 237; Super Nickel, 61; Tantalum, 11; Taurex Bronze, 62; Tophet C, 248; Tuf-Stuf, 64, .

**FERROUS SULPHATE:** Admiralty, 12; Alcumite, 15; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Barberite, 22; Bethadur 2, 71; Bethadur 6, 73; Bethadur 8, 74; Chemical Lead, 3; Chromium Iron, 93; Circle L 22, 106; Circle L 23, 107; Circle L 31, 109; Cyclops 17 Metal, 122; Defstain, 126; Deoxidized Copper, 4 & 5; Durimet, 131; Duriron, 132; Duronze, 26; Elcomet K, 135; Everdur, 28; Fine Silver, 7; G-60, 29; Hardware Bronze, 30; Hastelloy A, 138; Hastelloy C, 31; Hastelloy D, 32; High Brass, 33; Highloss C, 160; Illium, 35; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Mechanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 30-30, 180; Misco C, 184; Monel Metal, 37; Nickel, 10; Nickel Clad Steel, 192; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Ni-Resist,

per, 4 & 5; Duraloy A, 127; Duriron, 131; Duriron, 132; Duro Gloss C, 134; Elcomet K, 135; Empire 30, 140; Everbrite, 27; Everdur, 28; G-60, 29; Hardware Bronze, 30; Hastelloy C, 31; Heat Resisting St. 5, 159; High Brass, 33; Highloss C, 160; Highloss DD, 161; HR-5M, 162; Lesco 18-8 S, 165; Lesco 21-12, 166; Lesco 25-20, 167; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 30-30, 180; Misco C, 184; Monel Metal, 37; Nevastain KA2, 187; Nickel, 10; Nickel Clad Steel, 192; Nickel Silver 18%, 40; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Red Brass, 55; Red Brass 85%, 56; Rezistac, 57; Rezistal 3, 211; Rezistal 2600, 214; Rezistal 2C, 215; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Steel, 234; Sterling Nirosta, 236; Sterling Stainless St. F C, 237; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.

**FORMALDEHYDE:** Admiralty, 12; Alcumite, 15; Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Barberite, 22; Bethadur 1, 70; Bethadur 2, 71; Bethadur 4, 72; Bethadur 6, 73; Bethadur 8, 74; Bethadur 11, 160; Chromium Iron, 93; Circle L 11, 100; Circle L 12, 101; Circle L 13, 102; Circle L 14, 103; Circle L 15, 104; Circle L 22, 106; Circle L 23, 107; Circle L 31, 109; Defheat, 123; Defrust, 124; Defrust Spec., 125; Defstain, 126; Deoxidized Copper 4 & 5; Duraloy A, 127; Duraloy B, 128; Duraloy N, 129; Durco Nirosa, 130; Durimet, 131; Everdur, 28; Fine Silver, 7; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; HR-5M, 162; Hystensl Bronze, 33; Monel Metal, 37; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Ni-Resist, 194; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze, 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; Phosphor Bronze C, 50; Phosphor Bronze D, 51; Phosphor Bronze, 48; P-M-G Metal, 52; Red Brass 85%, 56; Rezistac, 57; Super Nickel, 61; Tantalum, 11; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64.

**HYDROCHLORIC ACID (Moderate dilution):** Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Chemical Lead, 3; Deoxidized Copper, 4; Duriron, 132; Everdur, 28; Fine Silver, 7; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; HR-5M, 162; Hystensl Bronze, 33; Monel Metal, 37; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Ni-Resist, 194; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze, 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; Phosphor Bronze C, 50; Phosphor Bronze D, 51; Phosphor Bronze, 48; P-M-G Metal, 52; Red Brass 85%, 56; Rezistac, 57; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64.

**HYDROCHLORIC ACID (Concentrated):** Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Deoxidized Copper, 4; Duriron, 132; Everdur, 28; Fine Silver, 7; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; Red Brass 85%, 56; Super Nickel, 61; Tantalum, 11; Tuf-Stuf, 64.

**HYDROCHLORIC ACID (Very dilute):** Admiralty, 12; Alcumite, 15; Aluminum Bronze, 18; Ambrac A, 19; Deoxidized Copper, 4 & 5; Everdur, 28; Fine Silver, 7; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; HR-5M, 162; Hystensl Bronze, 33; Monel Metal, 37; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; Red Brass 85%, 56; Rezistac, 57; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64.

194; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; R-50, 54; Red Brass, 55; Red Brass 85%, 56; Rezistac, 57; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2600, 214; Rezistal 2C, 215; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Steel, 234; Sterling Nirosta, 236; Sterling Stainless St. F C, 237; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.

**HYDROBROMIC ACID:** Admiralty, 12; Alcumite, 15; Aluminum Bronze, 18; Ambrac A, 19; Deoxidized Copper, 4 & 5; Everdur, 28; Fine Silver, 7; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; HR-5M, 162; Hystensl Bronze, 33; Monel Metal, 37; Nickel, 10; Nickel Clad Steel, 192; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; Red Brass 85%, 56; Rezistac, 57; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64.

**HYDROCHLORIC ACID (Very dilute):** Admiralty, 12; Alcumite, 15; Aluminum Bronze, 18; Ambrac A, 19; Deoxidized Copper, 4 & 5; Everdur, 28; Fine Silver, 7; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; HR-5M, 162; Hystensl Bronze, 33; Monel Metal, 37; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Ni-Resist, 194; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze, 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; Red Brass 85%, 56; Rezistac, 57; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64.

**HYDROCHLORIC ACID (Moderate dilution):** Aluminum Bronze, 18; Ambrac A, 19; Antimonial Lead, 20; Chemical Lead, 3; Deoxidized Copper, 4; Duriron, 132; Everdur, 28; Fine Silver, 7; Hastelloy A, 158; Hastelloy C, 31; Hastelloy D, 32; HR-5M, 162; Hystensl Bronze, 33; Monel Metal, 37; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Ni-Resist, 194; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze, 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; Phosphor Bronze C, 50; Phosphor Bronze D, 51; Phosphor Bronze, 48; P-M-G Metal, 52; Red Brass 85%, 56; Rezistac, 57; Super Nickel, 61; Sweetaloy 17, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64.

**HYDROGEN PEROXIDE (3 per cent):** Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Barberite, 2, 71; Chromax, 89; Chromium Iron, 93; Cyclops 17 Metal, 122; Davis Metal, 24; Deoxidized Copper, 4 and 5; Duraloy A, 127; Duraloy B, 128; Duraloy N, 129; Durco Nirosa, 130; Durimet, 131; Duriron, 132; Duro Gloss C, 133; Elcomet K, 135; Empire 30, 140; Everdur, 28; Fahrte N2, 152; G-60, 29; Hastelloy C, 31; Hastelloy D, 32; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; P-M-G Metal, 52; Red Brass 85%, 56; Super Nickel, 61; Tantalum, 11; Tophet A, 63; Tophet C, 248; Tuf-Stuf, 64.

**HYDROGEN PEROXIDE (100 per cent):** Allegheny 44, 66; Allegheny 55, 67; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Barberite, 2, 71; Chromax, 89; Chromium Iron, 93; Cyclops 17 Metal, 122; Davis Metal, 24; Deoxidized Copper, 4 and 5; Duraloy A, 127; Duraloy B, 128; Duraloy N, 129; Durco Nirosa, 130; Durimet, 131; Duriron, 132; Duro Gloss C, 133; Elcomet K, 135; Empire 30, 140; Everdur, 28; Fahrte N2, 152; G-60, 29; Hastelloy C, 31; Hastelloy D, 32; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Nickel, 10; Nickel Clad Steel, 192; Nirosa KA2, 199; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; P-M-G Metal, 52; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; Red Brass, 55; Red Brass 85%, 56; Rezistac, 57; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2600, 214; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Steel, 234; Sterling Nirosta, 236; Sterling Stainless St. F C, 237; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.

**HYDROGEN PEROXIDE (100 per cent):** Allegheny 44, 66; Allegheny 55, 67; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Barberite, 2, 71; Chromax, 89; Chromium Iron, 93; Cyclops 17 Metal, 122; Davis Metal, 24; Deoxidized Copper, 4 and 5; Duraloy A, 127; Duraloy B, 128; Duraloy N, 129; Durco Nirosa, 130; Durimet, 131; Duriron, 132; Duro Gloss C, 133; Elcomet K, 135; Empire 30, 140; Everdur, 28; Fahrte N2, 152; G-60, 29; Hastelloy C, 31; Hastelloy D, 32; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Nickel, 10; Nickel Clad Steel, 192; Nirosa KA2, 199; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; P-M-G Metal, 52; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; Red Brass, 55; Red Brass 85%, 56; Rezistac, 57; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2600, 214; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Steel, 234; Sterling Nirosta, 236; Sterling Stainless St. F C, 237; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.

**HYDROGEN PEROXIDE (100 per cent):** Allegheny 44, 66; Allegheny 55, 67; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Aluminum Bronze, 18; Ambrac A, 19; Barberite, 2, 71; Chromax, 89; Chromium Iron, 93; Cyclops 17 Metal, 122; Davis Metal, 24; Deoxidized Copper, 4 and 5; Duraloy A, 127; Duraloy B, 128; Duraloy N, 129; Durco Nirosa, 130; Durimet, 131; Duriron, 132; Duro Gloss C, 133; Elcomet K, 135; Empire 30, 140; Everdur, 28; Fahrte N2, 152; G-60, 29; Hastelloy C, 31; Hastelloy D, 32; Nickel Silver 18% A, 41; Nickel Silver 18% B, 42; Nickel Silver 18%, 40; Nickel, 10; Nickel Clad Steel, 192; Nirosa KA2, 199; Omega Nickel Silver 18% A, 43; Omega Nickel Silver 18% B, 44; Omega Phos. Bronze 30, 45; Omega Phos. Bronze 47, 46; Omega Phos. Bronze 209, 47; P-M-G Metal, 52; Phosphor Bronze, 48; Phosphor Bronze A, 49; Phosphor Bronze C, 50; Phosphor Bronze D, 51; Red Brass, 55; Red Brass 85%, 56; Rezistac, 57; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal 2600, 214; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Steel, 234; Sterling Nirosta, 236; Sterling Stainless St. F C, 237; Sweetaloy 17, 239; Tantalum, 11; Taurex Bronze, 62; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.

**IODINE:** Ambrac A, 19; Deoxidized Copper, 4; Duro Gloss C, 134; Everdur, 28; Hastelloy C, 31; Heat Resisting St. 5, 159; Higloss DD, 161; HR-5M, 162; Illium, 35; Meehanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 26-02, 179; Midvaloy 26-10, 177; Midvaloy 26-20, 178; Midvaloy 26-30, 179; Midvaloy 27-10, 177; Midvaloy 27-20, 178; Midvaloy 27-30, 179; Midvaloy 28-10, 177; Midvaloy 28-20, 178; Midvaloy 28-30, 179; Midvaloy 29-10, 177; Midvaloy 29-20, 178; Midvaloy 29-30, 179; Midvaloy 30-10, 177; Midvaloy 30-20, 178; Midvaloy 30-30, 179; Midvaloy 31-10, 177; Midvaloy 31-20, 178; Midvaloy 31-30, 179; Midvaloy 32-10, 177; Midvaloy 32-20, 178; Midvaloy 32-30, 179; Midvaloy 33-10, 177; Midvaloy 33-20, 178; Midvaloy 33-30, 179; Midvaloy 34-10, 177; Midvaloy 34-20, 178; Midvaloy 34-30, 179; Midvaloy 35-10, 177; Midvaloy 35-20, 178; Midvaloy 35-30, 179; Midvaloy 36-10, 177; Midvaloy 36-20, 178; Midvaloy 36-30, 179; Midvaloy 37-10, 177; Midvaloy 37-20, 178; Midvaloy 37-30, 179; Midvaloy 38-10, 177; Midvaloy 38-20, 178; Midvaloy 38-30, 179; Midvaloy 39-10, 177; Midvaloy 39-20, 178; Midvaloy 39-30, 179; Midvaloy 40-10, 177; Midvaloy 40-20, 178; Midvaloy 40-30, 179; Midvaloy 41-10, 177; Midvaloy 41-20, 178; Midvaloy 41-30, 179; Midvaloy 42-10, 177; Midvaloy 42-20, 178; Midvaloy 42-30, 179; Midvaloy 43-10, 177; Midvaloy 43-20, 178; Midvaloy 43-30, 179; Midvaloy 44-10, 177; Midvaloy 44-20, 178; Midvaloy 44-30, 179; Midvaloy 45-10, 177; Midvaloy 45-20, 178; Midvaloy 45-30, 179; Midvaloy 46-10, 177; Midvaloy 46-20, 178; Midvaloy 46-30, 179; Midvaloy 47-10, 177; Midvaloy 47-20, 178; Midvaloy 47-30, 179; Midvaloy 48-10, 177; Midvaloy 48-20, 178; Midvaloy 48-30, 179; Midvaloy 49-10, 177; Midvaloy 49-20, 178; Midvaloy 49-30, 179; Midvaloy 50-10, 177; Midvaloy 50-20, 178; Midvaloy 50-30, 179; Midvaloy 51-10, 177; Midvaloy 51-20, 178; Midvaloy 51-30, 179; Midvaloy 52-10, 177; Midvaloy 52-20, 178; Midvaloy 52-30, 179; Midvaloy 53-10, 177; Midvaloy 53-20, 178; Midvaloy 53-30, 179; Midvaloy 54-10, 177; Midvaloy 54-20, 178; Midvaloy 54-30, 179; Midvaloy 55-10, 177; Midvaloy 55-20, 178; Midvaloy 55-30, 179; Midvaloy 56-10, 177; Midvaloy 56-20, 178; Midvaloy 56-30, 179; Midvaloy 57-10, 177; Midvaloy 57-20, 178; Midvaloy 57-30, 179; Midvaloy 58-10, 177; Midvaloy 58-20, 178; Midvaloy 58-30, 179; Midvaloy 59-10, 177; Midvaloy 59-20, 178; Midvaloy 59-30, 179; Midvaloy 60-10, 177; Midvaloy 60-20, 178; Midvaloy 60-30, 179; Midvaloy 61-10, 177; Midvaloy 61-20, 178; Midvaloy 61-30, 179; Midvaloy 62-10, 177; Midvaloy 62-20, 178; Midvaloy 62-30, 179; Midvaloy 63-

MODERN METALS

Nirosta, 236; Tantalum, 11; Taurex Bronze, 62; Tophet A, 63; Tophet C, 248; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254; 100 Alloy, 258.

**MAGNESIUM CHLORIDE:** Admiralty, **12**; Allegheny **44, 66**; Aluminum Bronze, **18**; Ambrac **A, 19**; Antimonial Lead, **20**; Bethadur **7**; Chemical Lead, **3**; Circle L **11, 100**; Circle H **14, 103**; Davis Metal, **24**; Definistrut, **123**; Definistrut Spec., **125**; Defistain, **126**; Deoxidized Copper, **4** and **5**; Durco Nirosita, **130**; Durimelt, **131**; Duriron, **132**; Duro Gloss C<sub>2</sub>, **133**; Duro Gloss C<sub>3</sub>, **134**; Everdur, **28**; Fahrile N<sub>2</sub>, **152**; G-60, **29**; Hardware Bronze, **30**; Hastellloy A, **158**; Hastelloy C, **31**; Heat Resisting St. **5, 159**; High Brass, **33**; Highloss C, **160**; Highloss DD, **161**; HR-5M, **162**; Hy-Glo, **163**; Illium, **35**; Lesco H, **168**; Lesco HH, **169**; Lesco L, **170**; Lesco M, **171**; Lesco 18-S, **164**; Lesco 18-S-S, **165**; Lesco 21-12, **166**; Lesco 25-20, **167**; Meehanite Metal, **174**; Misco C, **184**; Monel Metal, **37**; Nickel, **10**; Nickel Clad Steel, **102**; Nickel Silver 18%, **40**; Nickel Silver 18% B, **41**; Nickel Silver 18% B, **42**; Ni-Resist, **194**; Nirosita KA2, **197**; Phosphor Bronze, **48**; Phosphor Bronze A, **49**; Phosphor Bronze C, **50**; Phosphor Bronze D, **51**; Red Brass, **55**; Red Brass 85%, **56**; Regular SS, **210**; Rezistal KA2, **216**; Rezistal KA2 Mo, **217**; Rezistal 2C, **215**; Rezistal 3, **211**; Rezistal 4, **212**; Rezistal 7, **213**; R-50, **54**; Stainless Iron, **226**; Stainless Steel, **234**; Sterling Nirosita, **236**; Super Nickel, **61**; Sweetaloy 17, **230**; Tantalum, **11**; Taurex Bronze, **62**; Tophet C, **248**; USS 12, **249**; USS 17, **250**; USS 18-S, **251**; USS 18-S stabilized, **252**; USS 25-12, **253**; USS 27, **254**.

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<b>190:</b> Nichrome IV	39:	Nirostal
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215:	Rezistal 7,	Rezistal 2C,
212:	Rezistal KA2,	213:
Rezistal KA2	20,	Stain-
216:	Rezistal KA2	217:
Stain-	220:	Steel
Steel	221:	T-700
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 130; Durimet, 131; Duriron, 132;  
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 140; Fahrte N 2, 152; G-60, 29;  
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68: Allegheny Metal,	69: Aluminum
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Antimonial Lead,	19: Bethadun
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Elecomet-K,	135: Empire 30,
Everdur,	140: Fine Silver
29: Hardware Bronze,	7: G-60
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St. 5,	159: Hytensal Bronze,
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165: Lesco 21-12,	164: Lesco
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Midvaloy 25-20,	177: Midvaloy
178:	26-02,
Midvaloy 30-30,	179: Misco C,
Monel Metal,	184: Nickel
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Clad Steel,	Nickel Silver 18%
192:	Nickel Silver 18% A,
40:	Nickel Silver 18% A, 41:
Silver 18% B,	42: Ni-Resist,
Nirosta KA2,	199: Phosphor Bronze
48:	Phosphor Bronze A,
Phosphor Bronze C,	49: Phosphor Bronze D,
51:	P-M-G Metal,
P-M-G Metal,	52: R-50,
Red Brass,	54: Red Brass 85%
Regular SS,	56: Rezistal 3,
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## MODERN METALS

**Chromax.** **89:** Circle L **22, 106:** Circle L **23, 107:** Circle L **31, 109:** Cyclops Metal **17, 122:** Davis Metal, **24:** Defirst, **123:** Defirst, **124:** Defirst, Spec., **125:** Defistain, **126:** Deoxidized Copper, **4** and **5:** Duraloy A, **127:** Duraloy B, **128:** Duraloy N, **129:** Durimet, **131:** Duriron, **132:** Duroc Nirosta, **130:** Duro Gloss C **2, 133:** Duro Gloss C **3, 134:** Duronze, **26:** Elecomet-K, **135:** Empire **30, 140:** Everdur, **28:** Fahrte, N-2, **152:** G-60, **29:** Genuine Wrought Iron, **8** and **9:** Hardware Bronze, **30:** Hastelloy A, **158:** Hastelloy C, **31:** High Brass, **33:** Heat Resisting St. **5, 159:** Higloss C, **160:** Higloss DD, **161:** HR-5M, **162:** Hy-Glo, **163:** Illum, **35:** Lesco **18-8, 164:** Lesco **18-8S, 165:** Lesco **21-12, 166:** Lesco **25-20, 167:** Lesco H, **168:** Lesco HH, **169:** Lesco L, **170:** Lesco M, **171:** Mechanite Metal, **174:** Midvaloy **13-00, 175:** Midvaloy **18-8, 176:** Midvaloy **25-10, 177:** Midvaloy **25-20, 178:** Midvaloy **30-30, 180:** Midvaloy **1835-A, 181:** Midvaloy **26-02, 179:** Midvaloy **ATV 1, 182:** Midvaloy **ATV 3, 183:** Misco C, **181:** Monel Metal, **37:** Nevastain KA2, **187:** Nevastain RA, **188:** Nichrome, **190:** Nichrome IV, **39:** Nickel, **10:** Nickel Clad Steel, **192:** Nickel Silver, **18% A, 40:** Nickel Silver **18% A, 41:** Nickel Silver **18% B-42:** Ni-Resist, **194:** Omega Nickel Silver, **18% A, 43:** Omega Nickel Silver, **18% B, 44:** Omega Phos. Bronze, **30, 45:** Omega Phos. Bronze, **47, 46:** Omega Phos. Bronze, **209:** Phosphor Bronze A, **49:** Phosphor Bronze C, **48:** Phosphor Bronze D, **51:** P-M-G Metal, **52:** Premier Nickel Chrome, **203:** R-50, **54:** Red Brass, **55:** Red Brass **85% 56:** Regular SS, **210:** Rezistal 3, **211:** Rezistal 4, **212:** Rezistal 7, **213:** Rezistal 2600, **214:** Rezistal 2C, **215:** Rezistal KA2, **216:** Rezistal KA2 Mo, **217:** Sivyer, **60, 218:** Stainless Iron, **226:** Stainless Iron 2 F.M., **227:** Stainless Iron 12, **228:** Stainless Iron 16, **229:** Stainless Iron 18, **230:** Stainless Iron 24, **231:** Stainless Steel, **234:** Stellite 1, **58:** Stellite 6, **59:** Stellite 12, **60:** Sterling Nirosta, **236:** Super Nickel, **61:** Sweetaloy, **17, 239:** Tantalum, **11:** Tantiron, **245:** Taurex Bronze, **62:** Tophet A, **63:** Tophet C, **248:** Tuf-Stuf, **64:** USS **17, 250:** USS **18-8, 251:** USS **18-8 Stabilized, 252:** USS **25-12, 253:** USS **27, 254:**

**SODIUM BISULPHATE:** Admiralty, **12:** Aluminum **28, 1:** Alclad, **14:** Aluminum **38, 17:** Aluminum Bronze, **18:** Ambrac A, **19:** Antimonic Lead, **20:** Chemical Lead, **3:** Davis Metal, **24:** Defistain, **126:** Deoxidized Copper, **4** and **5:** Duraloy A, **127:** Duraloy B, **128:** Duraloy N, **129:** Duroc Nirosta, **130:** Durimet, **131:** Duriron, **132:** Elecomet-K, **135:** Empire **30, 140:** Everdur, **28:** Fahrte N-2, **152:** G-60, **29:** Hardware Bronze, **30:** Hastelloy C, **31:** High Brass, **33:** Heat Resisting St. **5, 159:** Higloss C, **160:** Higloss DD, **161:** HR-5M, **162:** Hy-Glo, **163:** Illum, **35:** Midvaloy **18-8, 176:** Midvaloy **25-10, 177:** Midvaloy **25-20, 178:** Monel Metal, **37:** Nevastain KA2, **187:** Nevastain RA, **188:** Nickel, **10:** Nickel-Clad Steel, **192:** Nickel Silver, **18% A, 41:** Nickel Silver **18% B, 42:** Ni-Resist, **194:** Phosphor Bronze, **49:** Phosphor Bronze C, **50:** Phosphor Bronze D, **51:** P-M-G Metal, **52:** Red Brass, **55:** Red Brass **85% 56:** Regular SS, **210:** Rezistal 3, **211:** Rezistal 4, **212:** Rezistal 7, **213:** Rezistal 2S, **215:** Rezistal KA2, **216:** Rezistal KA2 Mo, **217:** Sivyer, **60, 218:** Stainless Iron, **226:** Stainless Iron 2 F.M., **227:** Stainless Iron 18, **230:** Stainless Iron 24, **231:** Stainless Steel, **234:** Standard Misco, **235:** Super Nickel, **61:** Sweetaloy, **17, 239:** Tantalum, **11:** Taurex Bronze, **62:** Tophet A, **63:** Tophet C, **248:** Tuf-Stuf, **64:** USS **17, 250:** USS **18-8, 251:** USS **18-8 Stabilized, 252:** USS **25-12, 253:** USS **27, 254:**

**SODIUM BISULPHITE:** Admiralty, **12:** Alcumite, **15:** Allegheny, **44, 66:** Allegheny Metal, **68:** Aluminum Bronze, **18:** Ambrac A, **19:** Davis Metal, **34:** Defistain, **126:** Deoxidized Copper, **4** and **5:** Duraloy N, **129:** Durimet, **131:** Elecomet-K, **135:** Everdur, **28:** Fahrte N-2, **152:** Hardware Bronze, **30:** Illum, **35:** Nickel Silver, **18% A, 41:** Nickel Silver **18% B, 42:** Ni-Resist, **194:** Phosphor Bronze, **49:** Phosphor Bronze C, **50:** Phosphor Bronze D, **51:** P-M-G Metal, **52:** Red Brass, **55:** Red Brass **85% 56:** Regular SS, **210:** Rezistal 3, **211:** Rezistal 4, **212:** Rezistal 7, **213:** Rezistal 2S, **215:** Rezistal KA2, **216:** Rezistal KA2 Mo, **217:** Sivyer, **60, 218:** Stainless Iron, **226:** Stainless Iron 2 F.M., **227:** Stainless Iron 18, **230:** Stainless Iron 24, **231:** Stainless Steel, **234:** Standard Misco, **235:** Super Nickel, **61:** Sweetaloy, **17, 239:** Tantalum, **11:** Taurex Bronze, **62:** Tophet A, **63:** Tophet C, **248:** Tuf-Stuf, **64:** USS **17, 250:** USS **18-8, 251:** USS **18-8 Stabilized, 252:** USS **25-12, 253:** USS **27, 254:**

**SODIUM CARBONATE:** Admiralty, **12:** Alcumite, **15:** Allegheny, **33:** Allegheny Metal, **67:** Allegheny Metal, **68:** Allegheny Metal, **69:** Aluminum Bronze, **18:** Ambrac A, **19:** Chromium Iron, **93:** Circle L **11, 100:** Circle L **12, 101:** Circle L **14, 103:** Circle L **15, 104:** Circle L **22, 106:** Circle L **23, 107:** Circle L **31, 109:** Circle L **32, 108:** Circle L **33, 109:** Circle L **34, 109:** Circle L **35, 110:** Circle L **36, 111:** Circle L **37, 112:** Circle L **38, 113:** Circle L **39, 114:** Circle L **40, 115:** Circle L **41, 116:** Circle L **42, 117:** Circle L **43, 118:** Circle L **44, 119:** Circle L **45, 120:** Circle L **46, 121:** Circle L **47, 122:** Circle L **48, 123:** Circle L **49, 124:** Circle L **50, 125:** Circle L **51, 126:** Circle L **52, 127:** Circle L **53, 128:** Circle L **54, 129:** Circle L **55, 130:** Circle L **56, 131:** Circle L **57, 132:** Circle L **58, 133:** Circle L **59, 134:** Circle L 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## MODERN METALS

**40:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** R-50. **54:** Red Brass. **55:** Red Brass 85%. **56:** Rezistal 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal 2C. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Sterling Nirosta. **236:** Super Nickel. **61:** Sweetaloy 17. **239:** Tantalum. **11:** Taurex Bronze. **62:** USS 18-8. **251:** USS 18-8 Stabilized. **252:** USS 25-12. **253:**

**SODIUM HYPOCHLORITE:** Ambrac A. **19:** Chromium Iron. **93:** Circle L 11. **100:** Circle L 14. **103:** Circle L 15. **104:** Circle L 22. **106:** Circle L 23. **107:** Defistain. **126:** Duriron. **132:** Duro Gloss C. **133:** Duro Glass C. **134:** Empire 30. **140:** Hastelloy C. **31:** HR-5M. **162:** Ilium. **35:** Lesco H. **168:** Lesco HH. **169:** Lesco L. **170:** Lesco M. **171:** Mechanite Metal. **174:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **177:** Midvaloy 25-20. **178:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Monel Metal. **37:** Nickel Clad Steel. **192:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Nirosta KA2. **199:** Super Nickel. **61:** Sweetaloy 17. **239:** Tantalum. **11:** USS 12. **249:** USS 17. **250:** USS 18-8. **251:** USS 18-8 Stabilized. **252:** USS 25-12. **253:** USS 27. **254:** 100 Alloy. **258:**

**SODIUM NITRATE:** Admiralty. **12:** Allegheny 33. **65:** Allegheny 44. **66:** Allegheny 55. **67:** Allegheny 66. **68:** Allegheny Metal. **69:** Aluminum 2S. **1:** Alcad. **14:** Aluminum 3S. **17:** Aluminum Bronze. **18:** Ambrac A. **19:** Bethadur 1. **70:** Bethadur 2. **71:** Bethadur 4. **72:** Bethadur 7. **73:** Bethadur 20. **215:** Bethadur 21. **216:** Chromium Iron. **93:** Circle L 11. **100:** Circle L 12. **101:** Circle L 13. **102:** Circle L 14. **103:** Circle L 15. **104:** Circle L 22. **106:** Circle L 23. **107:** Circle L 31. **109:** Defiheat. **123:** Defirst Spec. **125:** Defistain. **126:** Deoxidized Copper. **4 & 5:** Duro Nirosta. **130:** Durimet. **131:** Duriron. **132:** Duro Gloss C. **133:** Duro Gloss C. **134:** Elecomet K. **135:** Everdur. **28:** Fahrhite N-2. **152:** Genuine Wrought Iron. **8:** Hardware Bronze. **36:** Hastelloy C. **31:** Heat Resisting St. **5:** **159:** High Brass. **33:** Highloss C. **160:** Highloss DD. **161:** HR-5M. **162:** Hy-Glo. **163:** Ilium. **35:** Lesco 18-8. **164:** Lesco 18-SS. **165:** Lesco 21-12. **166:** Lesco H. **168:** Lesco HH. **169:** Lesco L. **170:** Lesco M. **171:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **177:** Midvaloy 25-20. **178:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Misco C. **184:** Monel Metal. **37:** Nevastain RA. **188:** Nickel. **10:** Nickel Clad Steel. **192:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Nirosta KA2. **199:** Phosphor Bronze. **48:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** R-50. **54:** Red Brass. **55:** Regular SS. **210:** Rezistal 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal 20. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Sivyer 60. **218:** Stainless Iron. **226:** Stainless Iron 2 F.M. **227:** Stainless Iron 12. **228:** Stainless Iron 16. **229:** Stainless Iron 18. **230:** Stainless Iron 24. **231:** Stainless Steel. **234:** Sterling Nirosta. **236:** Sweetaloy 17. **239:** Tantalum. **11:** Tantiron. **245:** Taurex Bronze. **62:** Tophet A. **63:** Tophet C. **248:** Tuf-Stuf. **64:** 100 Alloy. **258:**

**SODIUM PHOSPHATES:** Admiralty. **12:** Allegheny 33. **65:** Allegheny 44. **66:** Allegheny 55. **67:** Allegheny 66. **68:** Allegheny Metal. **69:** Aluminum Bronze. **18:** Ambrac A. **19:** Barberite. **22:** Chromium Iron. **93:** Circle L 11. **100:** Circle L 12. **101:** Circle L 13. **102:** Circle L 14. **103:** Circle L 15. **104:** Circle L 31. **109:** Davis Metal. **24:** Defiheat. **123:** Defirst Spec. **125:** Defistain. **126:** Deoxidized Copper. **4 & 5:** Duraloy N. **129:** Duro Nirosta. **130:** Durimet. **131:** Duro Gloss C. **132:** Duro Gloss C. **133:** Duro Gloss C. **134:** Elecomet K. **135:** Everdur. **28:** Fahrhite N-2. **152:** G-60. **29:** Hardware Bronze. **36:** Hastelloy C. **31:** Heat Resisting St. **5:** **159:** High Brass. **33:** Highloss C. **160:** Highloss DD. **161:** Hy-Glo. **163:** Ilium. **35:** Lesco 18-8. **164:** Lesco 18-SS. **165:** Lesco H. **168:** Lesco HH. **169:** Lesco L. **170:** Lesco M. **171:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **177:** Midvaloy 25-20. **178:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Misco C. **184:** Monel Metal. **37:** Nevastain RA. **188:** Nickel. **10:** Nickel Clad Steel. **192:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Nirosta KA2. **199:** Phosphor Bronze. **48:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** R-50. **54:** Red Brass. **55:** Regular SS. **210:** Rezistal 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal 20. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Sivyer 60. **218:** Stainless Steel. **234:** Sterling Nirosta. **236:** Sweetaloy 17. **239:** Tantalum. **11:** Tantiron. **245:** Taurex Bronze. **62:** Tophet A. **63:** Tophet C. **248:** Tuf-Stuf. **64:** 100 Alloy. **258:**

**164:** Lesco 18-8S. **165:** Lesco 21-12. **166:** Lesco 25-20. **167:** Lesco H. **168:** Lesco HH. **169:** Lesco L. **170:** Lesco M. **171:** Mechanite Metal. **174:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **177:** Midvaloy 25-20. **178:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Misco C. **184:** Monel Metal. **37:** Nichrome IV. **190:** Nickel. **10:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Omega Nickel Silver 18% A. **43:** Omega Nickel Silver 18% B. **44:** Omega Phos. Bronze 30. **45:** Omega Phos. Bronze 47. **46:** Omega Phos. Bronze 209. **47:** Phosphor Bronze. **48:** Phosphor Bronze A. **49:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** P-M-G Metal. **52:** R-50. **54:** Red Brass. **55:** Red Brass 85%. **56:** Rezistac. **57:** Rezistac 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal 2000. **214:** Rezistal 2 C. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Sivyer 60. **218:** Standard Misco. **235:** Sterling Nirosta. **236:** Super Nickel. **61:** Sweetaloy 20. **242:** Tantalum. **11:** Tantiron. **245:** Taurex Bronze. **62:** Tophet A. **63:** Tophet C. **248:** Tuf-Stuf. **64:** 100 Alloy. **258:**

**SODIUM SULPHIDE:** Allegheny 33. **65:** Allegheny 44. **66:** Allegheny 55. **67:** Allegheny 66. **68:** Allegheny Metal. **69:** Antimonial Lead. **70:** Bethadur 1. **70:** Bethadur 2. **71:** Bethadur 4. **72:** Bethadur 7. **73:** Bethadur 20. **215:** Bethadur 21. **216:** Chromium Iron. **93:** Circle L 22. **106:** Circle L 23. **107:** Circle L 31. **109:** Davis Metal. **24:** Defiheat. **123:** Defirst. **124:** Defirst Spec. **125:** Defistain. **126:** Deoxidized Copper. **4 & 5:** Duro Nirosta. **130:** Durimet. **131:** Duriron. **132:** Duro Gloss C. **133:** Duro Gloss C. **134:** Elecomet K. **135:** Everdur. **28:** Fahrhite N-2. **152:** G-60. **29:** Hastelloy C. **31:** Heat Resisting St. **5:** **159:** High Brass. **33:** Highloss C. **160:** Highloss DD. **161:** HR-5M. **162:** Ilium. **35:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **177:** Midvaloy 25-20. **178:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Misco HN. **185:** Monel Metal. **37:** Nichrome IV. **190:** Nickel. **10:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Omega Nickel Silver 18% A. **43:** Omega Nickel Silver 18% B. **44:** Omega Phos. Bronze 30. **45:** Omega Phos. Bronze 47. **46:** Omega Phos. Bronze 209. **47:** Phosphor Bronze A. **48:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** P-M-G Metal. **52:** R-50. **54:** Red Brass. **55:** Red Brass 85%. **56:** Rezistac. **57:** Rezistac 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal 2000. **214:** Rezistal 2 C. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Sivyer 60. **218:** Standard Misco. **235:** Sterling Nirosta. **236:** Super Nickel. **61:** Sweetaloy 20. **242:** Tantalum. **11:** Tantiron. **245:** Taurex Bronze. **62:** Tophet A. **63:** Tophet C. **248:** Tuf-Stuf. **64:** 100 Alloy. **258:**

**SULPHURIC ACID (Very dilute):** Admiralty. **12:** Alcumite. **15:** Aluminum 2S. **1:** Al-clad. **14:** Aluminum 3S. **17:** Aluminum Bronze. **18:** Ambrac A. **19:** Antimonial Lead. **20:** Barberite. **22:** Bethadur 2. **71:** Chromium Iron. **93:** Circle L 11. **100:** Circle L 13. **102:** Circle L 14. **103:** Circle L 15. **104:** Circle L 23. **107:** Circle L 31. **109:** Cyclops 17 Metal. **122:** Davis Metal. **24:** Defiheat. **123:** Defirst. **124:** Defirst Spec. **125:** Defistain. **126:** Deoxidized Copper. **4 & 5:** Duro Nirosta. **130:** Durimet. **131:** Duro Gloss C. **133:** Duro Gloss C. **134:** Elecomet K. **135:** Everdur. **28:** Fahrhite N-2. **152:** G-60. **29:** Hastelloy C. **31:** Heat Resisting St. **5:** **159:** Highloss C. **160:** Highloss DD. **161:** HR-5M. **162:** Ilium. **35:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **178:** Midvaloy 26-02. **179:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Misco HN. **185:** Monel Metal. **37:** Nichrome IV. **190:** Nickel. **10:** Nickel Clad Steel. **192:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Omega Nickel Silver 18% A. **43:** Omega Nickel Silver 18% B. **44:** Omega Phos. Bronze 30. **45:** Omega Phos. Bronze 47. **46:** Omega Phos. Bronze 209. **47:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** P-M-G Metal. **52:** R-50. **54:** Red Brass. **55:** Red Brass 85%. **56:** Rezistac. **57:** Rezistac 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal 2000. **214:** Rezistal 2 C. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Sivyer 60. **218:** Standard Misco. **235:** Super Nickel. **61:** Sweetaloy 20. **242:** Tantalum. **11:** Tantiron. **245:** Taurex Bronze. **62:** Tophet A. **63:** Tophet C. **248:** Tuf-Stuf. **64:** 100 Alloy. **258:**

**SULPHURIC ACID (Moderate dilution):** Alcumite. **15:** Aluminum 2S. **1:** Al-clad. **14:** Aluminum 3S. **17:** Aluminum Bronze. **18:** Ambrac A. **19:** Antimonial Lead. **20:** Barberite. **22:** Bethadur 2. **71:** Chromium Iron. **93:** Circle L 11. **100:** Circle L 12. **101:** Circle L 13. **102:** Circle L 14. **103:** Circle L 15. **104:** Circle L 23. **107:** Circle L 31. **109:** Cyclops 17 Metal. **122:** Davis Metal. **24:** Defiheat. **123:** Defirst. **124:** Defirst Spec. **125:** Defistain. **126:** Deoxidized Copper. **4 & 5:** Duro Nirosta. **130:** Durimet. **131:** Duro Gloss C. **133:** Duro Gloss C. **134:** Elecomet K. **135:** Everdur. **28:** Fahrhite N-2. **152:** G-60. **29:** Hastelloy C. **31:** Heat Resisting St. **5:** **159:** Highloss C. **160:** Highloss DD. **161:** HR-5M. **162:** Ilium. **35:** Lesco 18-8. **164:** Lesco 18-8S. **165:** Lesco 21-12. **166:** Lesco 25-20. **167:** Lesco H. **168:** Lesco HH. **169:** Lesco L. **170:** Lesco M. **171:** Mechanite Metal. **174:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **178:** Midvaloy 26-02. **179:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Misco HN. **185:** Monel Metal. **37:** Nevastain KA2. **187:** Nickel. **10:** Nickel Clad Steel. **192:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Omega Nickel Silver 18% A. **43:** Omega Nickel Silver 18% B. **44:** Omega Phos. Bronze 30. **45:** Omega Phos. Bronze 47. **46:** Omega Phos. Bronze 209. **47:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** P-M-G Metal. **52:** R-50. **54:** Red Brass. **55:** Red Brass 85%. **56:** Rezistac. **57:** Rezistac 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal 2000. **214:** Rezistal 2 C. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Sivyer 60. **218:** Standard Misco. **235:** Super Nickel. **61:** Sweetaloy 20. **242:** Tantalum. **11:** Tantiron. **245:** Taurex Bronze. **62:** Tophet A. **63:** Tophet C. **248:** Tuf-Stuf. **64:** 100 Alloy. **258:**

**SULPHURIC ACID (Concentrated):** Allegheny 44. **66:** Allegheny 66. **68:** Allegheny Metal. **69:** Aluminum Bronze. **18:** Ambrac A. **19:** Antimonial Lead. **20:** Chemical Lead. **3:** Chromax. **89:** Cyclops 17 Metal. **122:** Deoxidized Copper 4. **123:** Durimet. **131:** Duriron. **132:** Duro Gloss C. **133:** Duro Gloss C. **134:** Elecomet K. **135:** Everdur. **28:** Fahrhite N-2. **152:** G-60. **29:** Hastelloy C. **31:** Heat Resisting St. **5:** **159:** Highloss C. **160:** Highloss DD. **161:** Hy-Glo. **163:** Ilium. **35:** Lesco 18-8. **164:** Lesco 18-8S. **165:** Lesco 21-12. **166:** Lesco 25-20. **167:** Lesco H. **168:** Lesco HH. **169:** Lesco L. **170:** Lesco M. **171:** Mechanite Metal. **174:** Midvaloy 13-00. **175:** Midvaloy 18-8. **176:** Midvaloy 25-10. **177:** Midvaloy 26-02. **178:** Midvaloy 30-30. **180:** Midvaloy 1835-A. **181:** Misco HN. **185:** Monel Metal. **37:** Nevastain KA2. **187:** Nickel. **10:** Nickel Clad Steel. **192:** Nickel Silver 18%. **40:** Nickel Silver 18% A. **41:** Nickel Silver 18% B. **42:** Ni-Resist. **194:** Omega Nickel Silver 18% A. **43:** Omega Nickel Silver 18% B. **44:** Omega Phos. Bronze 30. **45:** Omega Phos. Bronze 47. **46:** Omega Phos. Bronze 209. **47:** Phosphor Bronze C. **50:** Phosphor Bronze D. **51:** P-M-G Metal. **52:** R-50. **54:** Red Brass. **55:** Red Brass 85%. **56:** Rezistac. **57:** Rezistac 3. **211:** Rezistal 4. **212:** Rezistal 7. **213:** Rezistal KA2. **214:** Rezistal KA2 Mo. **215:** Rezistal KA2. **216:** Rezistal KA2 Mo. **217:** Stainless Iron. **227:** Stainless Iron 16. **229:** Stainless Iron 18. **230:** Stainless Iron 24. **231:** Stainless Steel. **234:** Standard Misco. **235:** Sterling Nirosta. **236:** Super Nickel. **61:** Sweetaloy 20. **242:** Tantalum. **11:** Tantiron. **245:** Taurex Bronze. **62:** Tophet A. **63:** Tophet C. **248:** Tuf-Stuf. **64:** 100 Alloy. **258:**

**SULPHURIC ACID:** Admiralty. **12:** Allegheny 44. **66:** Allegheny 55. **67:** Allegheny 66. **68:** Allegheny Metal. **69:** Aluminum Bronze. **18:** Aluminum 2S. **1:** Alcad. **14:** Aluminum 3S. **17:** Ambrac A. **19:** Antimonial Lead. **20:** Chemical Lead.

**CIRCLE L 31. **109:** Deoxidized Copper. **4 & 5:** Durimet. **131:** Duro Gloss C. **133:** Duro Gloss C. **134:** Duronze. **26:** Everbrite. **27:** Everdur. **28:** Fine Silver. **7:** **60:** **29:** Hardware Bronze. **33:** Hastelloy C. **30:** Hastelloy A. **58:** Hastelloy D. **32:** Hastelloy E. **33:** Hastelloy F. **34:** Hastelloy G. **35:** Hastelloy H. **36:** Hastelloy I. **37:** Hastelloy J. **38:** Hastelloy K. **39:** Hastelloy L. **40:** Hastelloy M. **41:** Hastelloy N. **42:** Hastelloy O. **43:** Hastelloy P. **44:** Hastelloy Q. **45:** Hastelloy R. **46:** Hastelloy S. **47:** Hastelloy T. **48:** Hastelloy U. **49:** Hastelloy V. **50:** Hastelloy W. **51:** Hastelloy X. **52:** Hastelloy Y. **53:** Hastelloy Z. **54:** Hastelloy AA. **55:** Hastelloy BB. **56:** Hastelloy CC. **57:** Hastelloy DD. **58:** Hastelloy EE. **59:** Hastelloy FF. **60:** Hastelloy GG. **61:** Hastelloy HH. **62:** Hastelloy II. **63:** Hastelloy KK. **64:** Hastelloy LL. **65:** Hastelloy MM. **66:** Hastelloy NN. **67:** Hastelloy OO. **68:** Hastelloy PP. **69:** Hastelloy QQ. **70:** Hastelloy RR. **71:** Hastelloy TT. **72:** Hastelloy YY. **73:** Hastelloy ZZ. **74:** Hastelloy AAA. **75:** Hastelloy BBB. **76:** Hastelloy CCC. **77:** Hastelloy DDD. **78:** Hastelloy EEE. **79:** Hastelloy FFF. **80:** Hastelloy GGG. **81:** Hastel**

## Chem. &amp; Met. Data Sheets for CORROSION, HEAT AND ABRASION RESISTANT METALS AND ALLOYS

Methods of Fabrication: B = Brazing; Br = Burning; C = Casting; D = Drawing; DD = Deep Drawing; F = Flanging; Fr = Forging; R = Riveting; S = Soldering; SS = Soft Soldering; W = Welding.

Forms Available: B = Bar; C = Casting; CR = Cold Rolled; D = Drawn; FR = Forgings; HR = Hot Rolled; S = Sheets; T = Tubing; WR = Wire; WR = Welding Rod.

Footnotes: Small superior numbers (1, 2) refer to footnotes.

## MODERN METALS

No.	MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per Cent	Specific Gravity	Melting Point	Thermal Conductivity, Btu. per hr., per in. <sup>2</sup> , at 68° F.	Room Temp. Cond. Electr., G.C.S. ohm <sup>-1</sup>	Specific Heat, Btu. per lb. per °F.	Tensile Strength, Lb. per in. <sup>2</sup> , at 68° F.	Reduct. of Area, in.	Brittle modulus, Lb. per in. <sup>2</sup>	Form for which Tensile Prop. are Recorded	Machin.-Qualities	Method of Fabrication	Forms Available	Address and telephone No.			
1	METALS Aluminum 28	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 99	2.71	1215	1.3	0.53	0.222	Annealed sheet	13	4	35	21	Good	DD, F, R, W	B, CR, D, HR, P, S, T, W	Yes	1	
2	Armco Ingot Iron	Amer. Rolling Mill Co., Middleton, Ohio	Fe, 8, 0.025; Mn, 0.017; C, 0.012; P, 0.005	7.86	2785	0.016			Sheet and plate	48	32	65	30	80	Good	B, DD, F, R, W	B, CR, HR, P, S, T, W	2	
3	Chemical Lead	National Lead Co., New York, N. Y.	Pb, 99.9%; Cu, 0.06	620	1.61	0.08	0.03			23	1		2.6	4.5	Fair	F, R, 88A, W, T, W	B, C, CR, S	3	
4	Deoxidized Copper	Amer. Brass Co., Waterbury, Conn.	Cu, 99.90%; P, 0.01	8.90	1984	0.98	0.922	0.092	Rod, wire	55	44	35	60	16	42° Tough	B, DD, F, R, W	B, CR, D, HR, P, S, T, W	4	
5	Deoxidized Copper	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 99.9%; P, 0.02	8.92	1980	0.984	0.80	0.0917	Plate, sheet, tube	60	40	40	4	15	30	Tough	B, DD, F, R, W	B, C, CR, D, HR, P, S, T, W	5
6	Deoxidized Copper	Mueller Brass Co., Port Huron, Mich.	Cu, 99.9%; P, 0.01-0.04	8.86	1980	0.984			Tube	60	53	1.8			Fair	B, DD, F, W	T	6	
7	Fine Silver	Handy & Harman, New York, N. Y.	Ag, 99.9	10.53	1761	1.02	1.0	0.054	Hard sheet Annealed sheet	41	30	3	10	3	38	Good	B, DD, F, R, W	B, C, CR, D, P, S, T, W	7
8	Genuine Wrought Iron	A. M. Byers Co., Pittsburgh, Pa.	Fe, Ni, 5 max; Mn, <0.05; P, 0.10; Cr, <0.05; C, 0-0.75	7.65	2760	0.11				45	30	25			Good	B, F, R, W	B, CR, HR, P, S, T, W	Good	8
9	Genuine Wrought Iron	Reading Iron Co., Reading, Pa.	Fe, 98.8%; P, 0.05; C, 0.03; Si, 0.03; Mn, 0.03	7.86	2750	0.07	0.111		Bar	48		28			Good	B, F, R, W	B, CR, D, HR, P, S, T, W	9	
10	Nickel	International Nickel Co., New York, N. Y.	Ni, 99+	8.85	2640	0.72	0.14	0.130		65	29	100	30	30	Satisfactory	B, DD, F, R, W	B, C, CR, D, HR, P, S, T, W	10	
11	Tantalum	Fansteel Products Co., North Chicago, Ill.	Ta	16.0	5160	0.357	0.130	0.0365	Rod and wire	130	140	Up to 35	75			B, DD, F, R, W	B, CR, D, P, S, T, W	11	
12	NON-FERROUS Admiralty	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 70; Zn, 29; Sn, 1	8.54	1645	1.12	0.26	0.093	Tube	50	5	60	75	17	45° Fair	B, DD, F, R, W	B, CR, D, P, S, T, W	12	
13	Advance	Driver-Harris Co., Harrison, N. J.	Cu, 55; Ni, 45	8.9	2210	0.82	0.054	0.094	Wrought	60	40	45	120		Good	B, DD, F, R, W	B, CR, D, P, S, T, W	13	
14	Alclad 17ST	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 94; Cu, 4; Mg, 0.5; Mn, 0.5; coated with Al, 95% +	2.78	1000	1.2	0.27	0.225	Sheet	55	32	18	10		Satisfactory	DD, F, R, W	B, CR, D, HR, Low	14	
15	Alumite	Duriron Co., Dayton, Ohio	Cu, Al, 9; Fe, 1.25	7.75	1940	0.9	0.239		Cast	75	25	30	35	16.5	Lake steel		B, C, HR	15	
16	Alumic G	Seovill Mfg. Co., Waterbury, Conn.	Cu, 70; Zn, 27; Al, 2; Ni, 1	8.54	1645	1.12	0.26	0.093	Strip				15			CR, D, S, T, W	16		
17	Aluminum 3S	Aluminum Co. of Amer., Pittsburgh, Pa.	Al, 97; Mn, 1.26	2.73	1193	1.3	0.45	0.222	Annealed sheet Hard sheet	16	5	30	10	25	Gated	DD, F, R, W	B, CR, D, HR, P, S, T, W	17	
18	Aluminum Bronze	Amer. Brass Co., Waterbury, Conn.	Cu, 88-96; Al, 2.3-10.5; Fe, 8.18	1960	0.152-	0.181			Rod	55	30	4	60	Good	B, DD, F, R, W	B, CR, D, HR, P, S, T, W	18		
19	Ambra C	Amer. Brass Co., Waterbury, Conn.	Cu, 65; Ni, 20; Zn, 5	8.84	2160	0.91	0.092		Sheet, wire, rod	50	24	50	19	71	Good	B, DD, F, R, W	B, CR, D, HR, P, S, T, W	19	
20	Antimonial Lead (Hard Lead)	National Lead Co., New York, N. Y.	Pb, 94; Sb, 6	4.75	1190	0.9	0.239		Rolled	3	16	75	90		Good	B, BR, F, R, S, W	B, CR, D, HR, P, S, T, W	20	
21	Blackbar	Blackbar Co., Los Angeles, Calif.	W, C	16	3630-5430										Granular	Excell.	21		
22	Barberite	Barber Asphalt Co., Buffalo, N. Y.	Cu, 88.5; Ni, 5; Sn, 5; Sb, 1.5	8.8	1960				'cast bar'	58	46.5	7			Good	C	22		
23	Calite N	Calitropic Co., Pittsburgh, Pa.	Cu, 67; Ni, 25; Fe, 6; Mn, 1; Pb, 0.8; Sb, 0.3; C, 0.20 max.	8.22					Cast	60	35	18	24	120	Good		B, C, S	23	
24	Davis Metal	Chapman Valve Mfg. Co., Indian Orchard, Mass.	Fe, Ni, 64-68; Cr, 17-20														24		
25	Downmetal	Dow Chemical Co., Midland, Mich.	Mg, 89.8-95.7; Al, 4-10; Mn, 0.2	1.76	1100	1.4	0.16	0.24	Wrought	35	32	8	45	55	Excell.	R, W	B, CR, D, HR, P, S, T, W	25	
26	Duronize	Bridgeport Brass Co., Bridgeport, Conn.	Cu, 97; Sn, 2; Sb, 1	8.78	1905	0.933			Hard drawn rod	70	10	50			Like phosphorus bronze	B, DD, F, R, S, W	B, CR, D, HR, P, S, T, W	26	
27	Everbrite	Amer. Manganese Bronze Corp., Philadelphia, Pa.	Cu, 60; Ni, 30; Fe, 3; Sn, 3; Cr, 3	8.8					Cast	75	45	14	170	Good	C	Good	27		

# MODERN METALS

No.	Description	Chemical Analysis	Dimensions	Weight	Brinell		W		Brinell		W		HRC		HRc		C		HRc	
					Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast	Cast
26	Durende	Cu, 94.4; Ni, 3.4; Mn, 1.1	8.54	1830	0.94	0.078			50	203	5	30	15	60	Good	W	B, C, CR, D, Hit, P, S, T, W	B, DD, F, R, B, C, CR, D, Hit, P, S, T, W	28	
27	Everbrite	Cu, 94.4; Sn, 2; Cu, 2; Mn, 1	8.54	1830	0.94	0.060			145	95	50	80	15	200	Fair	B, R, W	C	Yes	29	
28	G-46	Ni, 63; Cr, 24; Cu, 5; Mo, 4; W, 2; Si, 0.80; Fe, 1; Mn, 0.20; C, 0.06	8.65	1860	1.01	0.032			58	15	50	16	60	200	Good	B	B, CR, D	B, CR, D	30	
29	Hardware Bronze	Chase Brass & Copper Co., Waterbury, Conn.	8.65	1920					60	40	70	120			Fair	B, R, W	C	Yes	29	
30	Hastelloy C	Ni, 58; Mo, 17; Cr, 14; Fe, 6; W, 5; Mn, 2; V, 2; Al, 1.5	8.78	2320	0.03				55	42	11	15			Machinable	W	C	C	31	
31	Hastelloy D	Ni, 85; Sn, 10; Cu, 3; Al, 1.5	8.78	2050	0.05				78							304		C	Yes	32
32	Hastelloy E	Kokomo, Ind.																		
33	High Brass	Chase Brass & Copper Co., Waterbury, Conn.	8.47	1660	1.13	0.29	0.093			47	5	75	17	45	Fair	W	B, DD, F, R, B, CR, D, S,	B, DD, F, R, B, CR, D, S,	33	
34	Hytenstal Bronze	Amer. Manganese Bronze Co., Cu, 63 <sup>1</sup> ; Zn, 23; Al, 4; Fe, 3; Mn, 3	7	0.9					110	65	15	14.5	220	Good		C, HR, S	Good	C, HR, S	34	
35	Ithium	Burgess-Parr Co., Moline, Ill.	Fe, Ni, 57; Cr, 22; Cu, 8; Mo, 4; Mn, 2; V, 2	8.3	2370	0.75	0.105		60											
36	Kona	Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.	Ni; Co, 18; Fe, 6; Ti, 2.5	8.58	2640	0.59														
37	Monel Metal	International Nickel Co., New York, N. Y.	Ni, 60-70; Cu, 25-35; Fe, 1-3; Mn, 0.25-2.0; Sn, 0.02-1.5	8.80	2370	0.8	0.06	0.127	65	25	14.5	20	170	Fair	W	C				
38	Mueller 600 Metal	Mueller Brass Co., Port Huron, Mich.		8.71	1625				60	30			200							
39	Nichrome IV	Driver-Harris Co., Harrison, N. J.	Ni, 80; Cr, 20	8.36	2550	0.73	0.036	0.104	100	65	35	20	150	Fair						
40	Nickel Silver 18%	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 65; Ni, 18; Zn, 17	8.75	2030	0.003	0.003		200	180										
41	Nickel Silver 18% A	Amer. Brass Co., Waterbury, Conn.	Cu, 65; Ni, 18; Zn, 17	8.75	2030	0.080			58	2	35	18	160							
42	Nickel Silver 18% B	Amer. Brass Co., Waterbury, Conn.	Cu, 55; Zn, 27; Ni, 18	8.68	1930				90	40	40	30	150	Fair						
43	Omega Nickel Silver 18% A	Riverside Metal Co., Riverside, N. J.	Cu, 65; Ni, 18; Zn, 17	8.75	2030				60	35	40	30	200							
44	Omega Nickel Silver 18% B	Riverside Metal Co., Riverside, N. J.	Cu, 55; Ni, 18; Zn, 27	8.50	1930	1.83			60	1.3	40	1.3	150	Fair						
45	Omega Phos. Bronze	Riverside Metal Co., Riverside, N. J.	Cu, 95.5; Sn, 4.3; P, 0.2	8.86	1920	1.75			55	1	40	1.3	150	Fair						
46	Omega Phos. Bronze	Riverside Metal Co., Riverside, N. J.	Cu, 91.6; Sn, 8.25; P, 0.15	8.79	1875	1.79			90	40	40	1.3	150	Fair						
47	Omega Phos. Bronze	Riverside Metal Co., Riverside, N. J.	Cu, 90; Sn, 10; P	8.70	1830	1.80			60	1.3	40	1.3	150	Fair						
48	Phosphor Bronze	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 95; Sn, 5	8.85	1670	0.98	0.15	0.093	100	65	35	15	150	Fair						
49	Phosphor Bronze A	Amer. Brass Co., Waterbury, Conn.	Cu, 95; Sn, 5; P	8.87	1904	0.95	0.160		60	2	40	1.3	150	Fair						
50	Phosphor Bronze C	Amer. Brass Co., Waterbury, Conn.	Cu, 92; Sn, 8; P	8.82	1877	0.96	0.150		110	55	55	18	140	Fair						
51	Phosphor Bronze D	Amer. Brass Co., Waterbury, Conn.	Cu, 89.5; Sn, 10.5; P	8.78	1832	0.98	0.121		60	23	97	18	140	Fair						
52	P-M-G Metal	Phelps-Dodge Copper Prod. Corp., New York, N. Y.	Cu, Sn, Fe	8.42	1900	0.97			110	55	55	18	140	Fair						
53	Q-Alloy A +	General Alloys Co., Boston, Mass.	Ni, 68-69; Cr, 19-21	8.65	2275-2625	0.70	0.014	0.114	120	85-	28	45								
54	R-56	La Bour Co., Elkhart, Ind.	Ni, 54; Cr, 24; Fe, 10; Cu, 5; Mo, 3.6; W, 1.8; Sn, 0.80; Mn, 0.30	8.73	1815-1885	1.04	0.36	0.093	120	80-	50	50	16	40	Fair	B, R, W	C	Yes	54	
55	Red Brass 85%	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 85; Sn, 15	8.75	1868	0.98	0.380		75	2	40	140								
56	Red Brass 86%	Amer. Brass Co., Waterbury, Conn.	Cu, 88; Al, 10; Fe, 2	7.7	0.89				50	20-	4	43								
57	Resistac	Amer. Manganese Bronze Co., Philadelphia, Pa.							75	36	18	18	160							
58	Stellite 1	Haynes Stellite Co., Kokomo, Ind.	Co, 50; Cr, 30; W, 15.5	8.59	2280	0.090			40	0	5									
59	Stellite 6	Haynes Stellite Co., Kokomo, Ind.	Co, 65; Cr, 30; W, 4	8.38	2360	0.100			86											
60	Stellite 12	Haynes Stellite Co., Kokomo, Ind.	Co, 60; Cr, 30; W, 8	8.40	2360	0.100			66											
61	Super Nickel	Amer. Brass Co., Waterbury, Conn.	Cu, 70; Ni, 30	8.96	2237	0.90			65	30										
62	Tauver Bronze	Chase Brass & Copper Co., Waterbury, Conn.	Cu, 98.5; Sn, 1.5	8.90	1830	1.0	0.44	0.093	120	80-	4	45-	140							

# MODERN METALS

No.	MATERIAL	MANUFACTURER (Name and Address)	Essential Nominal Chemical Composition, Per cent		Specific Gravity	Melting Point	Recom. Temp.	Therm. Cond.	Therm. Cond.	Therm. Cond.	Therm. Cond.	Tensile Strength, per cent	Yield Point, per cent	Elongation, per cent	Reduc. of Area,	Reduc. per in., in.	Brittle modulus,	Brittle hardness	Methods of Fabrication	Forms Available	Absorption, %	No.
			Ni	Cr																		
63	Tophet A	Gilby Wire Co., Newark, N. J.	Ni, 80; Cr, 20	8.42	2530	0.73							165	90	3	45					D, HR, P, S, W	63
64	Tuf-Stuff	Mueler Bros. Co., Port Huron, Mich.	Cu, 85-89; Al, 8-14; Fe, 2-4; Mn	7.62	1875-1900								120	90	3	45					B, D	64
65	FERROUS Allegheny 33	Allegheny Steel Co., Brackenridge, Pa.	Fe, Cr, 12-16; Mn, 0.50; C, 0.12	2710-0.60	0.096	0.150	Annealed bar	75	45	35	75	28	150	Good						B, DD, F, R, B, C, CR, D, HR, P, S, T, W	65	
66	Allegheny 44	Allegheny Steel Co., Brackenridge, Pa.	Fe, Cr, 20-30; Ni, 10-20; Mn, 1.0; C, 0.20 max.	2532-0.9	0.030	0.142	Annealed bar	90	45	60	70	29.5	140	Good						B, DD, F, R, B, G, CR, D, Yes, HR, P, S, W	66	
67	Allegheny 55	Allegheny Steel Co., Brackenridge, Pa.	Fe, Cr, 26-30; Ni, 0.60 max.; Mn, 1.0 max.; C, 0.25 max.	2605-0.56	0.050		Annealed bar	75	45	35	75	28	150	Good						B, F, R, W, B, CR, D, S, HR, P, S, T, W	67	
68	Allegheny 66	Allegheny Steel Co., Brackenridge, Pa.	Fe, Cr, 15-18; Mn, 0.50 max.; C, 0.12	2714-0.58	0.082		Annealed bar	70	40	35	70	28	140	Good						B, DD, F, R, B, CH, D, HR, P, T, W	68	
69	Allegheny Metal	Allegheny Steel Co., Brackenridge, Pa.	Fe, Cr, 16-20; Ni, 7-10; Mn, 0.50 max.; C, 0.12 max.	2606-0.96	0.050		Annealed bar	90	45	60	70	28.6	135	Fair						B, DD, F, R, B, CH, D, HR, P, S, T, W	69	
70	Bethadur 1	Bethlehem Steel Co., Bethlehem, Pa.	Fe, Cr, 12.5; Mn, 0.30; C, 0.11	7.68	2690	0.605	0.118	Annealed bar	110	95	68	20	20	220	Good					B, S	70	
71	Bethadur 2	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 18; Ni, 8; Mn, 0.30; Co, 0.13	7.89	2690		0.118	Annealed bar <sup>2</sup>	95	57	42	75	29	150	Fair					B, DD, F, R, D, FT, HR, W	71	
72	Bethadur 4	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Mn, 0.30; Cr, 17; C, 0.11	7.65	2680		0.118	Annealed bar	75	58	28	62	29	170	Fair					B, DD, F, R, D, Pr, HR, W	72	
73	Bethadur 6	Bethlehem Steel Co., Bethlehem, Pa.	Fe; Cr, 14; C, 0.40; Mn, 0.30	7.75	2680		0.118	Annealed bar <sup>1</sup>	118	73	21	54	29	235	Good					B, D, FT, HR	73	
74	Bethadur 8	Fe; Cr, 18; Mn, 0.30; C, 1.15	2690		0.118	Annealed bar	118	78	16	19	29	241	Fair						D, FT, HR	74		
75	Bethadur 9	Fe; Cr, 28; Mn, 0.30; C, 0.30	2690	0.68	0.118	Annealed bar	95	50	18	22	29	187	Fair						B, D, FT, HR, W	75		
76	Bethalon	Fe; Cr, 14; Ni, 0.50 max.; Mn, 0.30; C, 0.11	7.68	2690	0.60	0.118	Annealed bar	85	55	30	50	29	159	Free mach.	R, S				B, D, FT, HR, Yes, W	76		
77	Calite A	Fe; Ni, > 34.0; Cr, > 14.9	7.86		0.96									200	Good				C, B	77		
78	Calite B	Fe; Cr, > 20.9; Ni, > 8.9;	7.65																B, C, S	78		
79	Calite B-28	Fe; Cr, 24-26; Ni, 8-10																	B, S	79		
80	Calite E	Fe; Cr, > 17.9; Ni, > 7.9	7.86	0.61															B, S	80		
81	Calite S	Fe; Ni, 18	7.67	0.61									75	50	35	55	175			B, P, S	81	
82	Carpenter Stainless Steel 1	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 12-14; C, 0.10	7.78	2715	0.57	0.090	0.152	Annealed <sup>1</sup>	85	60	30	77	28.5	175	Good				B, DD, F, R, B, CR, D, HR, T, W	82	
83	Carpenter Stainless Steel 2	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 12-14; C, 0.30	7.75	2690				Hardened bar	260	225	11	32		512	Good				B, F, R, W, B, CR, D, HR, T, W	83	
84	Carpenter Stainless Steel 3	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 20; Cu, 1; C, 0.30	7.19	2685	0.55			All forms	100	50	22	55	28	190	Good				B, DD, F, R, B, CR, D, HR, T, W	84	
85	Carpenter Stainless Steel 4	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 18; Ni, 9.5; C, 0.10	7.71	2550	0.88	0.052	0.118	Annealed	89	35	63	72	28	135	Fair				B, DD, F, R, B, CR, D, HR, T, W	85	
86	Carpenter Stainless Steel 5	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 14; ZnS, 0.40; C, 0.10	7.78	2715	0.63	0.096	0.152	Annealed <sup>1</sup>	86	63	25	58	28	187	Free mach.	B, F, R, W, B, CR, D, HR, W			B, CR, D, Yes	86	
87	Carpenter Stainless Steel 6	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 17; C, 0.10	7.73	2715	0.65	0.07		All forms	80	45	27.5	62	28	170	Good				B, DD, F, R, B, CR, D, HR, T, W	87	
88	Carpenter Stainless Steel 8	Carpenter Steel Co., Reading, Pa.	Fe; Cr, 18; Ni, 9; Se, 0.25; C, 0.10	7.86	2550	0.88	0.052	0.118	Annealed <sup>2</sup>	95	55	45	56	28	149	Free mach.	B, F, R, W, B, CR, D, HR, W			B, CR, D, Yes	88	
89	Chromax	Driver-Harris Co., Harrison, N. J.	Fe; Ni, 35; Cr, 15	8.15	2895				Cast	60	35	2	168	Good						B, C, CR, HR, W	89	
90	Chromax	Empire Steel Castings, Reading, Pa.	Fe; Cr, 1.25; Ni, 0.50; Mo, 0.35; C, 0.35							90-100	25-30	500-600			500-600	Good				Grood	90	
91	Chromel 502	Hoskins Mfg. Co., Detroit, Mich.	Fe, Cr, 48; Ni, 30-34; Cr, 18-22; Mn, 2; C, 0.50 max.	7.84	2450	0.95			Cast	65-75	3		160-180						B, C, CR, D, HR, W	91		
92	Chrome Stainless	Warman Steel Casting Co., Huntington Park, Calif.	Fe; Cr, 17	7.7			0.151	Cast <sup>1</sup>	90	45	15	30							C	92		

## MODERN METALS

93 Chromium Iron	Babcock & Wilcox Tube Co., New York, N. Y.	Fe; Cr, 16.5-18.5; Si, 1.25 max.; Mn, 0.50 max.; C, 0.12 max.	7 67	2750	Tube	—	70 min.	45 min.	25 min.	175 max.	Good	DD, F, R, W, T		
94 Chromium Steel 4-6%	Babcock & Wilcox Tube Co., New York, N. Y.	Fe; Cr, 4-6%; Mo, 0.4-0.6%; Si, 0.5 max.; Mn, 0.5 max.; C, 0.2 max.	7 83	2650	Tube	—	65 min.	30 min.	35 min.	170 max.	Good	T		
95 Circle L-3	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 1.25; Mo, 0.40; C, 0.45 C, 0.5-0.8	7 84	2625-0 62	0 125	Cast	110-250	85-200	5-18	500	Good	B, W		
96 Circle L-4	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 1.25-2%; Mo, 0.5-1%; C, 0.5-0.8	7 84	0 62	0 125	Cast	125-275	90-225	3-12	600	Good	B, W		
97 Circle L-6	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Ni, 1.75; Mo, 0.25; C, 0.18	7 84	0 125	Cast	67	20	40	—	Good	C	Yes		
98 Circle L-8	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 1.5; V, 0.50%; C, 0.25	7 84	2625-0 64	0 125	Cast	90-200	60-150	6-20	50	Good	C	Yes	
99 Circle L-10	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 5%; Mo, 0.50%; C, 0.20	7 83	2650-0 66	0 110	Cast	120	90	17	45	Good	B, W	Yes	
100 Circle L-11	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 18.5%; C, 0.25	7 60	2600-0 55	0 063	0 15	Cast	100	75	8	10	Good	B, W	C
101 Circle L-12	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 13%; Ni, 0.50 max.; C, 0.10	7 78	2600-0 56	0 066	0 152	Cast	75-95	45-60	18-24	30-50	Good	W	C
102 Circle L-13	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 13%; Ni, 0.50 max.; C, 0.35	7 75	0 55	0 120	Cast	170-200	120-150	3-10	15	Good	C	Yes	
103 Circle L-14	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 20%; Cu, 1.0%; Ni, 0.50 max.; C, 0.30	7 69	2600-0 55	0 063	0 15	Cast	95	68	6	7	Good	W	C
104 Circle L-15	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 28.5%; Ni, 0.50 max.; C, 0.30	7 50	2600-0 56	0 064	0 15	Cast	60	35	3	4	Good	W	C
105 Circle L-16	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 28%; C, 2.25	7 45	2550-0 56	0 064	0 15	Cast	68	26	50	50	Fair <sup>4</sup>	B, W	C
106 Circle L-22	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 19%; Ni, 9%; C, 0.07 max.	7 80	2575-0 89	0 063	0 12	Cast	75	35	50	50	Fair <sup>4</sup>	W	C
107 Circle L-23	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 19%; Ni, 9%; C, 0.15	7 80	2550-0 89	0 063	0 12	Cast	60	25	50	50	Fair <sup>4</sup>	W	C
108 Circle L-24	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Ni, 20%; Cr, 9%; C, 0.15	8 00	2600-1 0	0 074	0 07	Cast	83	47	15	10	Fair <sup>4</sup>	B, W	C
109 Circle L-31	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 28%; Ni, 11%; C, 0.25	7 90	2625-0 78	0 025	Cast	75	30	7	7	Good	W	C	
110 Circle L-32	Lebanon Steel Foundry, Lebanon, Pa.	Fe; Cr, 16%; Ni, 35%; C, 0.50	8 00	2575-0 78	0 11	Cast	60	25	40	28	Fair <sup>4</sup>	B, W	C	
111 Colonial 410	Colonial 410 F	Fe; Cr, 13.5%; Ni, 8.02%; C, 0.12 max.	7 76	2650-0 570	0 050	Heat treated bar	128	113	21	55	Good	B, DD, F, R, W	C	
112 Colonial 410 F	Colonial 410 F	Fe; Cr, 13.5%; Ni, 8.02%; C, 0.12 max.	7 76	2650-0 570	0 050	Heat treated bar	130	110	18	50	Good	B, CR, D, W	111	
113 Colonial 430	Colonial 430	Fe; Cr, 13.5%; Ni, 1; Mo, 0.60%; C, 0.35	7 77	2600-0 588	0 052	Heat treated bar	235	205	9	23	Fair <sup>4</sup>	B, CR, D, W	112	
114 Colonial 610	Colonial 610	Fe; Cr, 17%; Ni, 1; C, 0.12 max.	7 80	2650	0 610	Annealed bar	78	51	32	61	Good	B, CR, D, W	113	
115 Colonial 610 F	Pittsburgh, Pa. Vanadium-Alloy Steel Co., Latrobe, Pa.	Fe; Cr, 17%; Ni, 1; S, 0.25%; C, 0.12 max.	7 80	2650	0 610	Rolled bar	76	49	28	49	Free mach.	B, R, W	114	
116 Colonial 795	Colonial 795	Fe; Cr, 17.25%; Ni, 1; C, 0.95	7 72	2550	0 610	Heat treated bar	210	180	5	9	Good	B, CR, D, W	115	
117 Colonial C-2	Colonial C-2	Fe; Cr, 17%; C, 0.12 max.	7 80	2650	0 610	Annealed bar	75	50	32	55	Good	B, CR, D, W	116	
118 Colonial C-2 F	Colonial C-2 F	Fe; Cr, 17%; S, 0.25%; C, 0.12 max.	7 80	2650	0 610	Annealed bar	75	50	30	52	Free mach.	B, R, W	117	
119 Colonial F M S	Colonial F M S	Fe; Cr, 13.5%; S, 0.25%; C, 0.12 max.	7 74	2650	0 570	0 050	Heat treated bar	119	107	19	62	Free mach.	B, R, W	118
120 Corrosion	Pacific Foundry Co., San Francisco, Calif.	Fe; Si, 14.25%; C, 0.8-1	7 02	2460	—	—	0	0	0	300	Machinable	C	Yes	
121 Crocus	Vanadium-Alloy Steel Co., Latrobe, Pa.	Fe; Cr, 12%; C, 2.2%; V, 0.80%; Co, 0.50	7 68	2500	—	—	—	—	—	—	Yes	121		
122 Cyclops 17 Metal	Cyclops Steel Co., Titusville, Pa.	Fe; Ni, 20%; Cr, 8%; Si, 1; Mn, 0.75%; C, 0.15-0.45	8 00	2685	0 93	Bars	81-125	65-100	25-52	68-248	Good	B, DD, F, R, W	122	
123 Defheat	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 25-29%; Mn, 0.25-0.8%; C, 0.02 max.	7 62	—	—	Annealed bars	70-90	45-60	15-30	55-210	Fairly good	F, R	123	
124 Defrust	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 12-14.5%; Ni, 0.50 max.; Mn, 0.25-0.6%; C, 0.10 max.	7 78	—	0.09	Annealed bars	76	45	30	76	Good	B, CR, D, HR, P, S, T, W	124	
125 Defrust, special	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 10-18%; Ni, 0.50 max.; Mn, 0.25-0.6%; C, 0.10 max.	7 71	—	0.06	Annealed bars	75	44	37	70	Fair	DD, F, R, W	125	
126 Defstain	Rustless Iron Corp., Baltimore, Md.	Fe; Cr, 18-20%; Ni, 8-10%; Mn, 0.25-0.6%; C, 0.18 max.	7 93	—	0.048	Annealed bars	98	33	65	70	Fair	DD, F, R, W	126	
127 Duratoy A	Duratoy Co., Pittsburgh, Pa.	Fe; Cr, 27-30%; Mn, 0.60%; C	7 60	2650	0 57	Rolled Cast	80-90	60-70	10-27	15-45	Good	DD, R, W	127	

MODERN METALS

No.	MATERIAL (Name and Address)	Essential Nominal Chemical Composition, Per Cent	Specific Gravity	Melting Point, °F.	Specific Heat, Btu-lb., per ft. <sup>2</sup> , per sec.	Thermal Conductivity, C.G.S. Units, $\frac{1}{\text{deg}} \cdot \text{ft} \cdot \text{lb.}^{-1} \cdot \text{sec.}^{-1}$	Mean Coeff. Thermal Expansion, $\frac{1}{\text{deg}} \cdot \text{in.}^{-1} \cdot \text{in.}^{-1}$	Room Temp. Resist. to Oxidation, % per hr.	Tensile Prop. are Recorded	Form for which Tensile Prop. are Recorded	Reduced Weight per moduli, lb. per in. per in.	Reduced Elongation, % per in.	Reduced Hardness, lb. per in. per in.	Methods of Fabrication	Forms Available	Heat Treatment	No.
128	Duratoz B	Fe, Cr, 16-18; C, 0.61	7.60	2600	0.90	0.640	Rolled	85-95	65-75	25-35	150	Good	DD, F, R, W	B, C, C.R.D, Fair	128		
129	Duratoz N	Fe, Cr, 24; Ni, 12; C, < 0.07	7.6	2600	0.90	0.640	Rolled	80-90	60-70	10-19	160	Fair	DD, F, R, W	B, C, C.R.D, Fair	129		
130	Durco-Nirosta	Fe, Cr, 19; Ni, 9; Mn, 0.50; C, Cu, 1, C, 0.07	7.77	2600-0.9	0.058	0.12	Cast	95-130	50-105	45-65	150	Fair	H, R, W	C	130		
131	Durimet	Fe, Ni, 22; Cr, 20; Si, 3; Mn, 1; C, 0.15	7.80	2600-0.8	0.052	0.12	Cast	70	30	40-50	140	Fair <sup>2</sup>	W	B, DD, F, R, B, C, HR, P, W	131		
132	Durtron	Fe, Si, 14.5; C, 0.8; Mn, 0.35	7.0	2375	0.36	0.125	Cast	70	30	40-50	130	Fair <sup>3</sup>	W	B, DD, F, R, B, C, HR, P, W	132		
133	Duro Gloss C-2	Fe, Cr, 16-18; Mn, 0.25-0.40; C, 0.12	7.7	2720	0.61	0.07	0.151	Annealed bar	75-85	40-50	40-50	155	Good	H, DD, F, R, B, CR, D, W	B, DD, F, R, B, CR, D, W	133	
134	Duro Gloss C-3	Fe, Cr, 18-23; Mn, 0.25-0.40; C, 0.15	7.70	2750	0.65	0.07	0.150	Annealed bar	70	45-55	30-40	165	Fair	H, DD, F, R, B, CR, D, W	B, DD, F, R, B, CR, D, W	134	
135	Elcomet K	Mo, 2; Si, 12.5; Mn, 0.30; C, 0.13	7.7	2650	0.94	0.029	0.116	Cast	80-100	50-75	50-75	170	Good	R, W	C	135	
136	Empire 18	Fe, Cr, 18; C, 0.20	7.7	2650	0.94	0.029	0.116	Cast	80-100	50-75	50-75	170	Good	R, W	C	136	
137	Empire 18-8	Fe, Cr, 17; Ni, 8; C, 0.15	7.85	2650	0.94	0.029	0.116	Cast	80-100	50-75	50-75	170	Good	R, W	C	137	
138	Empire 24-12	Fe, Cr, 24; Ni, 12; C, 0.25	7.8	2650	0.94	0.029	0.116	Cast	90	45	15-20	170	Good	W	Unmachinable	138	
139	Empire 25-5	Fe, Cr, 28; Ni, 2; C, 2	7.7	2500	0.94	0.029	0.116	Cast	90	45	0	0	Good	R, W	C	139	
140	Empire 30	Fe, Cr, 30; C, 0.30	7.60	2700	0.94	0.029	0.116	Cast	50	40	1-2	180	Good	R, W	C	140	
141	Empire 35-15	Fe, Cr, 35; Ni, 15; C, 0.35	7.92	2550	0.75	0.045	0.045	Cast	70	8	3	180	Good	C	141		
142	Empire 60-20	Fe, Cr, 60; Ni, 20; Fe, 20; C, 0.50	8.1	2460	0.94	0.029	0.116	Cast	80-90	50-60	20-30	180	Good	C	142		
143	Empire D	Fe, Cr, 28; Ni, 16; Mo, 4	7.9	2700	0.94	0.029	0.116	Cast	60	40	1-2	180	Good	C	143		
144	Enduro AA	Fe, Cr, 15-18; C, 0.10 max.; Si, 0.50 max.; C, 0.10 max.	7.89	2725	0.53	0.045	0.045	Annealed	80	30	2-3	180	Good	E, R, W	B, C.R.D.HR, P, S, T, W	144	
145	Enduro HC	Fe, Cr, 25-30; Mn, 0.50 max.; Si, 0.30 max.; C, 0.20 max.	7.89	2730	0.56	0.03	0.035	Annealed	80	45	2-5	170	Fair	E, R, W	B, C.R.D.HR, P, S, T, W	145	
146	Enduro HCN	Fe, Cr, 22-25; Ni, 10-13; Mn, 1.5; Si, 0.50 max.; C, 0.20 max.; max.; Fe, Cr, 16-20; Ni, 7-10; Si, 0.75; max.; Mn, 0.50 max.; C, 0.16 max.	7.89	2550	0.9	0.03	0.03	Annealed	85	35	50 min.	163	Fair	DD, F, R, W	B, C.R.D.HR, P, S, T, W	146	
147	Enduro KA-2	Fe, Cr, 25-30; Mn, 0.50 max.; Si, 0.30 max.; C, 0.20 max.	7.89	2550	0.88	0.035	0.035	Annealed	100	50	45	170	Fair	E, R, W	B, C.R.D.HR, P, S, T, W	147	
148	Enduro KNC-3	Fe, Cr, 23-27; Ni, 17-21; Si, 2.4 max.; Mn, 1.50 max.; C, 0.20 max.	7.89	2000	1.06	0.03	0.03	Annealed	90	40	50	170	Fair	E, R, W	B, C.R.D.HR, P, S, T, W	148	
149	Enduro S-FC	Fe, Cr, 12-15; Mn, 0.50 max.; Si, 0.50 max.; C, 0.12 max.	7.89	2715	0.56	0.05	0.05	Annealed <sup>1</sup>	75	40	25	159	Free mach.	F, R, W	B, C.R.D.HR, P, S, T, W	149	
150	Evanssteel 2	Chicago St. Fdry. Co., Chicago, Ill.	8.13	2550	0.75	0.031	0.110	Cast	60	30	25-30	163	Good	W	B, C, HR, P, Yes S, T	150	
151	Fahrite N-1	Ohio St. Fdry. Co., Springfield, Ohio	Fe, Ni, 38; Cr, 18; Mn, 0.5-1; C, .3-1	7.80	2550	0.92	0.065	0.116	Annealed	80	38	10-30	175	Good	B, C, HR, P, Yes S, T	151	
152	Fahrite N-2	Ohio St. Fdry. Co., Springfield, Ohio	Fe, Cr, 18; Ni, 8; Mn, 0.50; C, .15-0.25	7.80	2550	0.75	0.025	0.110	Annealed	75	40	25	170	Fair only	E, R, W	B, C, HR, P, Yes S, T	152
153	Fahrite N-3	Ohio St. Fdry. Co., Springfield, Ohio	Fe, Cr, 24; Ni, 9; Mn, 0.35-0.75; C, 0.2-1	8.00	2730	0.74	0.07	0.07	Annealed	90	375	12-5	18	20	152 Fair <sup>2</sup>	W	153
154	Fahrite N-4	Ohio St. Fdry. Co., Springfield, Ohio	Fe, Ni, 20; Cr, 8; Mn, 0.5-0.75; C, 0.40	8.06	2575	0.034	0.034	0.034	Cast	60	46	1-2	190	Fair	W	C	154
155	Fire Armor	Michigan Products Corp., Michigan City, Ind.	Fe, Ni, 60; Cr, 20; C, 0.50 max.	8.06	2550	0.92	0.065	0.116	Annealed	80	38	38	180	Fair	D, F, R, W	C, B, S	155
156	Fire Armor B	Michigan Products Corp., Michigan City, Ind.	Fe, Ni, 60; Cr, 12; C, 0.50 max.	8.0	2380	0.033	0.033	0.033	Cast	58	45	3	2	Fair	D, F, R, W	C, B, S	156
157	Hascrome	Haynes Stellite Co., Kokomo, Ind.	Fe, Ni, 44; Cr, 12; Mn, 4	7.66	2450	0.033	0.033	0.033	Weld metal	40	45	500	230-500	Excell.	G, HR, P, S, WR	157	
158	Hastelloy A	Haynes Stellite Co., Kokomo, Ind.	NI, 58; Fe, 20; Mn, 20; Mn, 2	8.8	2470	0.04	0.04	0.04	Forged, annealed	110-120	47-52	34	207	Good	D, F, R, W	B, C, D, Fair P, S, T, W	158

## MODERN METALS

	Kokomo, Ind.	Haynes Steel Co., Kokomo, Ind.	Ni. 58; Fe. 20; Mn. 20; Mn. 2	8.8	2370 2425	0.04	Forged, annealed	110 120	47 52	30 48	35 54	207 Good	B. DD, F. R. B. C. D. HR. P. S. T. W.	158	
159 Heat Resisting St. 5	Jessop Steel Co., Washington, Pa.	Fe. Cr. 22-25; Ni. 10-14; C. 0.25 max.	7.40	2552- 2597	0.90	0.030	0.142	Annealed bar	105- 120	50- 60	45- 60	60- 75	140- 175	Fair	159
160 Higloss C.	Jessop Steel Co., Washington, Pa.	Fe; Cr. 18; Ni. 8; Mn. 0.35; C. 0.10	7.88	2550- 2600	0.90	0.06	0.118	Rolled bar	105- 120	60- 90	35- 45	28- 30	196- 228	Fair	160
161 Higloss DD	Jessop Steel Co., Washington, Pa.	Fe; Cr. 12; Ni. 12; Mn. 0.35; C. 0.10	7.86	2550- 2600	0.83	0.06	0.118	Annealed bar	90- 100	45- 55	60- 70	150- 160	Fair	161	
162 HR-SM	Standard Alloy Co., Cleveland, Ohio	Fe; 50; Cr. 25; Ni. 20; Mn. 2.5-4; Mn. 0.40; C. 0.30	7.80	>2800	0.85	0.108	Cast	62	51	18	13	190- 210	Fair	162	
163 Hy-Glo	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 17; C. 0.62; Mn. 0.36; Si. 0.5 max.	7.79	2724	0.61			Annealed bar	100	70	20	50	187	Good	163
164 Lesco 18-8	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 18.5; Ni. 8.5; Mn. 0.40; Si. 0.50 max.; C. 0.20 max.	7.88	2550	0.89	0.046	0.118	Annealed bar	87	33	58	70	28.5	143 Fair	164
165 Lesco 18-8 S	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 18.5; Ni. 8.5; Mn. 0.40; Si. 0.50 max.; C. 0.07 max.	7.88	2550	0.89	0.046	0.118	Annealed bar	87	33	58	70	28.5	143 Fair	165
166 Lesco 21-12	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 21; Ni. 12; Mn. 0.40; Si. 0.50 max.; C. 0.20 max.	7.86	0.89	0.040	0.142	Annealed bar	90	40	45	62	156	Fair	166	
167 Lesco 28-20	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 15; Ni. 20; Mn. 0.40; Si. 0.55 max.; C. 0.20 max.	7.61	2724	0.58			Annealed bar	117	57	40	54	217	Fair	167
168 Lesco H	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 19; Mn. 0.4; Si. 0.5 max.; C. 0.10 max.	7.60	2804	0.57			Annealed bar	74	50	27.5	61	163	Fair	168
169 Lesco HH	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 27; Mn. 0.4; Si. 0.5 max.; C. 0.20 max.	7.60	2804	0.57			Annealed bar	70	45	30	60	163	Fair	169
170 Lesco I	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 12; Mn. 0.4; Si. 0.5 max.; C. 0.10 max.	7.65	2724	0.72			Annealed bar	78	65	25	65	170	Good <sup>a</sup>	170
171 Lesco M	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr. 15-18; Mn. 0.4; Si. 0.5 max.; C. 0.10 max.	7.63	2724	0.72			Annealed bar	66	44	25	65	162	Good	171
172 Low Chrome	Warman Steel Casting Co., Huntington Park, Calif. <sup>111</sup>	Fe; Cr. 5	7.7					Cast	90	65	15	35	Good	C	172
173 Machemrite	Mackintosh Hemphill Co., Pittsburgh, Pa.	Fe; Ni. 1.5-3.5; Mn. 0.7-4.3%; Cr. 0-25; Mo. 0-0.5; C. 0.4-3%	7.60	2400- 2600	0.557- 0.64	0.105- 0.13	Bar	200	165	28	45	B. R. W.	C	173	
174 Meehanite Metal	Mechanite Metal Corp., Chattanooga, Tenn. See licensees	Fe; C. 3.0; Si. 0.5-6.0; Mn. 0.4-2%; S. 0.05-0.12; P. 0.05-0.10	7.49	2615- 0.58	0.035			Wrought	110	88	3	22	150- 600	Like gray iron	174
175 Midvaloy 13-90	Midvale Co., Philadelphia, Pa.	Fe; Cr. 15 or less; C. 0.12 or less	7.82	2725	0.7	0.096	0.15- 0.16	Wrought	70- 200	40- 165	13- 28	53- 70	180- 400	Good	175
176 Midvaloy 18-8	Midvale Co., Philadelphia, Pa.	Fe; Cr. 18; Ni. 9; C	7.86	2550	0.88	0.05	0.12	Wrought Cast	75- 70	42- 85	0- 3	5- 3	130-280	Fair	176
177 Midvaloy 25-10	Midvale Co., Philadelphia, Pa.	Fe; Cr. 24; Ni. 11;	7.86	0.90				Forged	115	45	25-	50	150- 240	Fair	177
178 Midvaloy 25-20	Midvale Co., Philadelphia, Pa.	Fe; Cr. 25; Ni. 19.5; C. 0.12	7.80					Wrought	100	40	25-	50	170- 200	Fair	178
179 Midvaloy 26-02	Midvale Co., Philadelphia, Pa.	Fe; Cr. 26.5; Ni. 1.5; C. 0.25	7.60					Cast	75- 100	60	20-	40-	165- 200	Fair	179
180 Midvaloy 30-30	Midvale Co., Philadelphia, Pa.	Fe; Cr. 27; Ni. 30; C. 0.50	7.84					Cast, annealed	42.5				Difficult	W	180
181 Midvaloy 4835-A	Midvale Co., Philadelphia, Pa.	Fe; Ni. 35; Cr. 18; C. 0.35	7.68	0.74				Cast	55- 65	40	5-	10-	150- 170	Fair	181
182 Midvaloy A.T.V. I	Midvale Co., Philadelphia, Pa.	Fe; Ni. 36; Cr. 11-15; C. 0.35	8.05	2640	0.020			Wrought Cast	88-110	50-68	20-35	30-54	170-185	Good	182
183 Midvaloy A.T.V. 3	Midvale Co., Philadelphia, Pa.	Fe; Ni. 26.5; Cr. 14; W. 3.5%; C. 0.48	8.12	0.78	0.104	0.068		Wrought	100- 112	45- 70	40-	45-	185- 238	Good	183
184 Misco C	Michigan Sheet Casting Co., Detroit, Mich.	Fe; Ni. 57; Cr. 30; Ni. 10; Mn. 0.60%; C. 0.25	7.87	2695- 0.72	0.031	0.114		Cast	95	65	25	33	175-185	Fair	184
185 Misco HN	Mishikan Steel Casting Co., Detroit, Mich.	Fe; Cr. 16-20; Si. 0.3-1; Mn. 0.60%; max.; C. 0.10, max.	8.12	2590- 2680	0.60	0.068		Cast, annealed	130	105	25	35	240-250	Fair	185
186 Nevastain A		Fe; Cr. 16-20; Si. 0.3-1; Mn. 0.60%; max.; C. 0.25	7.67	2750	0.60	0.068		Bar, flat stock	70- 80	40-	25-	50-	160- 200	Good	186
187 Nevastain KA2	Associated Alloy St. Co., Cleveland, Ohio	Fe; Cr. 16-20; Si. 0.15; Mn. 0.50	7.86	2550	0.89	0.032	0.118	Bar, flat stock	160	45	60	60	140- 200	Fair	187
188 Nevastain RA	Ludlum Steel Co., Waterbury, N. Y.	Fe; Cr. 16-17; Cu. 1; Si. 1; Mn. 0.50%; C. 0.05-0.12	7.67	2750	0.56	0.080		Bar, flat stock	70- 100	40-	20-	60	150- 230	Good <sup>a</sup>	188
189 Nevastain S		Fe; Cr. 11-13.5; Si. 0.30-1.1; Mn. 0.30 max.; Cu. 0.1-1; C. 0.12 max.	7.77	2750	0.56	0.07	0.11	Bar	100- 160	90-	10-	40-	230- 380	Good <sup>a</sup>	189
190 Nichrome	Driver-Harris Co., Harrison, N. J.	Ni. 60; Fe. 25; Cr. 15	8.19	2462	0.76	0.0325	0.107	Wrought	90- 175	35-	35	35	Good	B. DD, F. R. B. C. CR. D. HR. P. S. T. W.	190
191 Nickel-Chromium Cast Iron	International Nickel Co., New York, N. Y.	Fe; Ni. 1.5-1.75; Cr. 0.6-0.8; C. 3- <0.5; Si. 0.9-1.75; Mn. 0.5-0.7; P. C. 0.05-0.12	7.3	2150- 2250	1-01			Cast	35- 48	0	0	19- 22	170- 230	Good	191
192 Nickel-clad Steel	Lukens Steel Co., Coatesville, Pa.	Pure nickel cladding on steel base	8.0	2550	0.72	0.11		Plate	55- 65	40- 50	52- 62	30	575- 750	Good	192
193 Ni-Hard	International Nickel Co., New York, N. Y.	Fe; Ni. 4.4-4.6%; C. 2.75-3.6%; Cr. 1.4-1.6%; Si. 0.5-1.5; Mn. 0.3-0.7	7.40	2150- 2250	0.70			Cast	30- 40	0	0	575- 750	Fair	193	

MODERN METALS

No.	MATERIAL (Name and Address)	Essential Nominal Chemical Composition, Per Cent	Specific Gravity	Electrical Resistivity	Specific Heat, C.G.S. Units	Thermal Conductivity, C.G.S. Units	Room Temperature, Room Temp., C.G.S. Units	Form for which Tensile Prop. are Recorded	Machin.-ing Qualities	Methods of Fabrication	Forms Available	No.					
194	Ni-Resist	International Nickel Co., New York, N.Y. Licensees C, 2.75; Mn, 1.15; Si, 1.25; Cr, 1.5-4; Cu, 5-7; Fe, Ni, 15-20; Cr, up to 2.5; C, 2.2-3; Mn, 1.15; Si, 0.6-2	7.5-7.6	2150-2275	Cast	20-35	Up to 0	17-19	Good	C	C	194					
195	Ni-Resist, Copper-Free	International Nickel Co., New York, N.Y.	7.5-7.6	2275	Cast	29-35	Up to 0	17-19	Good	C	C	195					
196	Nirosta Calidro KA1	Warman Steel Casting Co., Huntington Park, Calif. II	Fe; Cr, 13; Ni, 1.75 optional	7.8	0.096	0.117	Cast	80-110	60-90	10-30	Fair	C	196				
197	Nirosta Calmar KA2	Warman Steel Casting Co., Huntington Park, Calif. II	Fe; Cr, 18; Ni, 8	7.9	0.089	0.035	Cast	70-100	50-55	27-28	Fair	C	197				
198	Nirosta Caloxo KNc3	Warman Steel Casting Co., Huntington Park, Calif. II	Fe; Cr, 25; Ni, 20	7.3	0.111	Cast	75	35	25	27-28	Fair	C	198				
199	Nirosta KA2	Babcock & Wilcox Tube Co., New York, N.Y.	Fe; Cr, 16.5-20; Ni, 7-10.5; Si, 0.75 max.; Mn, < 0.6; C, < 0.16	7.86	2550	0.118	Tube	85 min.	50 min.	175 max.	Good	DD, F, R, W, T	199				
200	Nitrolloy 125-135	Crucible Steel Co., New York, N.Y.	Fe; Al, 0.9-1.4; Cr, 0.9-1.4; Mn, 0.4-0.6; Mo, 0.15-0.25; C, 0.2-0.4	7.93	-	-	Heat treated bar	153	137	15	51	30	306	Good	B, DD, F, R, P, S, W	200	
201	Nitrolloy 225 and FM 225	Crucible Steel Co., New York, N.Y.	Fe; Al, 1.15; Mn, 0.4-0.7; Mo, 0.6-1; C, 0.25-0.35	7.70	2500	-	Heat treated bar	120	100	20	67	30	Very good	DD, F, R, W, B, CR, D, HR, P, S, W	201		
202	Ohio Air Die	Vanadium-Alloys Steel Co., Latrobe, Pa.	Fe; Cr, 12; C, 1.55; V, 0.85; Mo, 0.80; Co, 0.40	7.70	-	-	Wire, rod, strip	100	60	25	50	-	-	Yes	202		
203	Premier Nickel Chrome	Alloy Metal Wire Co., Moore, Pa.	Ni, 60-62; Fe, 25; Cr, 14-16; C, 0.10	7.66	-	-	-	-	-	-	-	B, CR, W	403				
204	Pyramet	Chicago St. Fab'y. Co., Chicago, Ill.	Fe; 57; Ni, 25; Cr, 15; C, 0.3	7.87	2640	0.95	-	62	10	18	-	DD, F, R, W, H, G, HR, S, T, W	204				
205	Pyrocast	Pacific Foundry Co., San Francisco, Calif.	Fe; Cr, 20 or over; Ni	7.55	2550	-	-	65	65	0	0	Good	C	205			
206	Q Alloy Chrome C 1	General Alloy Co., II Boston, Mass.	Fe; Cr, 26-30	7.60	2650	0.085	0.142	Cast	80	40	3	4	180	Fair	R, W	206	
207	Q Alloy Chrome C 2	General Alloy Co., II Boston, Mass.	Fe; Cr, 16-18	7.7	2750	0.081	0.155	Cast	60	55	12	17	205	Good	R, W	207	
208	Q Alloy Chrome CN 1	General Alloy Co., II Boston, Mass.	Fe; Cr, 24-26; Ni, 11-13	7.90	2570-2680	0.91	0.134	Cast	65	40	10-27	45	180	Good	DD, F, R, W, B, C, D, HR, P, S, T, W	208	
209	Q Alloy Chrome CN 2	General Alloy Co., II Boston, Mass.	Fe; Cr, 18-20; Ni, 8-10	7.85	2550-2660	0.88	0.118	Cast	60	35-40	10-40	210	160	Good	DD, F, R, W, B, C, D, HR, P, S, T, W	209	
210	Regular SS	Latrobe Elec. St. Co., Latrobe, Pa.	Fe; Cr, 13.5; Mn, 0.35; Si, 0.50	7.75	2724	0.61	Annealed bar	90	48	28	60	30	179	Good	B, DD, F, R, B, CR, E, H, R, W	210	
211	Resistal 3	Crucible Steel Co., New York, N.Y.	Fe; Cr, 25; Ni, 12; Si, 2.25; C, 0.2 max.	7.72	-	-	Bar	105	65	30	45	30	180	Fair	B, DD, F, R, B, CR, D, H, R, P, S, W	211	
212	Resistal 4	Crucible Steel Co., New York, N.Y.	Fe; Ni, 25; Cr, 18; Si, 2.25; C, 0.2 max.	7.85	-	-	Bar	100	50	30	40	200	160	Fair	B, DD, F, R, B, CR, D, H, R, P, S, W	212	
213	Resistal 7	Crucible Steel Co., New York, N.Y.	Fe; Cr, 25; Ni, 20; Si, 1; C, 0.15 max.	7.73	-	-	Bar	100	50	50	55	30	170	Fair	B, DD, F, R, B, CR, D, H, R, P, S, W	213	
214	Resistal 2600	Crucible Steel Co., New York, N.Y.	Fe; Ni, 22.5; Cr, 9; Cu, 1.25; C, 0.30	7.85	-	0.07	Bar	95	55	30	50	200	165	Fair	B, CR, D, Y	214	
215	Resistal 2C	Crucible Steel Co., New York, N.Y.	Fe; Cr, 18; Ni, 8; Si, 2.25; C, 0.15 max.	7.79	0.89	Bar <sup>2</sup>	95	50	60	60	30	150	Fair	B, DD, F, R, B, CR, D, H, R, P, S, W	215		
216	Resistal KA2	Crucible Steel Co., New York, N.Y.	Fe; Cr, 18; Ni, 8; Mn, 0.65; C, 0.15 max.	7.86	2550	0.89	0.052	Bar <sup>2</sup>	90	35	55	70	30	135	Fair	B, DD, F, R, B, CR, D, H, R, P, S, T, W	216
217	Resistal KA2 Mo	Crucible Steel Co., New York, N.Y.	Fe; Cr, 18; Ni, 8; Mo, 3; C, 0.15 max.	7.87	0.052	Bar <sup>2</sup>	95	45	55	70	30	175	Good	B, W	217		
218	Slyver 60	Slyver St. Casting Co., Milwaukee, Wis.	Fe; Cr, 18-8; Ni, 8; Mn, < 0.50; C, < 0.12	7.85	2600-2650	0.90	0.112	Cast	70	30	50	50	135	Good	B, W	218	
219	Slyver 62	Slyver St. Casting Co., Milwaukee, Wis.	Fe; Cr, 23-25; Ni, 11-13; Mn, < 0.15; C, < 0.15	7.80	2600-2700	0.90	-	Cast	75	40	60	70	150	Fair	C	219	
220	Slyver 66	Slyver St. Casting Co., Milwaukee, Wis.	Fe; Cr, 12-14; Mn, < 0.5; C, < 0.12	7.7	2600-2700	0.58	-	Cast	75	45	50	50	175	Good	B, W	220	
221	Slyver 67	Slyver St. Casting Co., Milwaukee, Wis.	Fe; Cr, 16-18; C, < 0.2	7.6	2600-2700	-	-	Cast	85	55	10-70	35-55	160	Fair	C	221	
222	Slyver 70	Slyver St. Casting Co., Milwaukee, Wis.	Fe; Cr, 13.5-17; C, < 0.16	7.74	2600	0.588	0.052	Cast	60	70	1	8	225	Fair	C	222	
223	Stainless A	Colonial Steel Co., Pittsburgh, Pa.	Colonial Steel Co., Pittsburgh, Pa.	7.74	2600	0.588	0.052	Heat treated bar	226	195	9	22	461	Good	B, R, W	223	
		Latrobe, Pa.															

## MODERN METALS

224	Stainless B	Colonial Steel Co., Pittsburgh, Pa. Vanadium-Alloys St. Co., Latrobe, Pa.	Fe; Cr, 16.5; C, 0.65 Fe; Cr, 13.5; C, 0.12 max.	7.74 7.74	2575 2650	0.606 0.57	0.050			Heat treated bar Heat treated bar	210 116	175 104	6 22	10 70	440 241	Good Good	B, R, W B, CR, D, HR, P, S, W	Yes Yes	224 225
225	Stainless I	Amer. Stainless Steel Co., Pittsburgh, Pa. See licensees	Fe; Cr, 8.80; Mn, 0.35; C, < 0.13 Fe; Cr, 14-15; Mn, 0.55; C, 0.11 Fe; Cr, 11.5-15; C, 0.12 max.	7.73 7.73	2640 2640	0.606 0.606			Rolled bars	50 80	35- 45	30- 35	75 75	250- 600	Good Free mach.	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	226 227	
226	Stainless Iron	Crucible Steel Co., New York, N. Y.	Fe; Cr, 15-18; C, 0.10 max.	7.75					Bar	90 140	55- 100	19- 28	62 55	30 30	160- 170	Good Good	B, DD, F, R, B, CR, D, HR, P, S, T, W	F, R, W F, R, W	228 228
227	Stainless Iron 2 FM	Crucible Steel Co., New York, N. Y.	Fe; Cr, 18-23; C, 0.10 max.	7.70					Bar <sup>1</sup>	87- 182	60- 179	18- 31	63- 74	30 40	170- 400	Good Good	B, CR, D, HR, P, S, T, W	F, R, W Fair	229 229
228	Stainless Iron 12	Crucible Steel Co., New York, N. Y.	Fe; Cr, 23-30; C, 0.25 max.	7.60					Bar	75- 85	45- 55	35- 45	60- 70	30 30	155- 170	Good Good	DD, F, R, W B, CR, D, HR, P, S, T, W	DD, F, R, W B, CR, D, HR, P, S, T, W	230 230
229	Stainless Iron 16	Crucible Steel Co., New York, N. Y.	Fe; Cr, 18-23; C, 0.10 max.	7.72					Bar	70- 80	45- 55	30- 40	50- 60	30 30	165- 185	Good Good	DD, F, R, W B, CR, D, HR, P, S, T, W	DD, F, R, W B, CR, D, HR, P, S, T, W	231 231
230	Stainless Iron 18	Crucible Steel Co., New York, N. Y.	Fe; Cr, 23-30; C, 0.25 max.	7.60					Bar <sup>2</sup>	80- 90	55- 65	30- 30	40- 50	30 30	170- 200	Good Good	DD, F, R, W B, CR, D, HR, P, S, T, W	DD, F, R, W B, CR, D, HR, P, S, T, W	232 232
231	Stainless Iron 24	Crucible Steel Co., New York, N. Y.	Fe; Cr, 18.5; Ni, 9; C, 0.12 max.	7.82	2660	0.887	0.035		Annealed bar	92	49	58	70	155	Fair	B, F, DD, R, B, CR, D, HR, P, W	B, F, DD, R, B, CR, D, HR, P, W	233 233	
232	Stainless N	Colonial Steel Co., Pittsburgh, Pa. Vanadium-Alloys St. Co., Latrobe, Pa.	Fe; Cr, 19; Ni, 9; Mn, 1.50; Cm, 1.25; C, 0.12 max.	7.83	2680	0.890	0.035		Annealed bar	87	41	52	72	150	Fair	B, DD, F, R, B, CR, D, P, P, S, T, W	B, DD, F, R, B, CR, D, P, P, S, T, W	234 234	
233	Stainless U	Amer. Stainless Steel Co., Pittsburgh, Pa. See licensees	Fe; Cr, 8-60; Mn, 0.40; C, > 0.12	7.75	2640	0.606			Rolled bars	80- 250	45- 150	10- 15	30- 35	150- 250	Good	B, C, CR, D, HR, P, S, W	B, R, W B, CR, D, HR, P, S, W	235 235	
234	Stainless Steel	Michigan Steel Casting Co., Detroit, Mich.	Fe; 46; Ni, 35; Cr, 15; Mn, 0.50; C, 0.60	7.92	2605- 2685	0.75	0.0247	0.112	Cast Rolled	75 100	70 81	3 42	6	180-190	Fair	F, R, W B, C, DHF, P, S, W	F, R, W B, DD, F, R, B, CR, D, P, P, S, W	236 236	
235	Standard Misco	Firth-Sterling St. Co., McKeesport, Pa.	Fe; 73; Cr, 18; Ni, 8; C, 0.15	7.93					Cast	109- 215	34- 170	13- 65	35	235-245	Good	B, DD, F, R, B, CR, D, HR, P, S, W	B, DD, F, R, B, CR, D, HR, P, S, W	237 237	
236	Sterling Nitrosta	Firth-Sterling St. Co., McKeesport, Pa.	Fe; Cr, 14; Mn, 0.40; C, 0.10	7.78	2660	0.60	0.030	0.15	Annealed	75	45	32	55	150	Good	B, R, W B, CR, D, HR, P, S, W	B, R, W B, CR, D, HR, P, S, W	238 238	
237	Sterling Stainless Steel FC	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 83; Cr, 16; Mn, 0.50; Si, 0.50; C, 0.35	7.60	2550- 2660	0.61			Cast	75	50	10	15	200	Good	C	C	239 239	
238	Sweetaloy 16	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 73; Cr, 18; Ni, 8; Min, 0.50; Si, 0.50; C, < 0.20	8	2600	0.90			Cast	79	47	23	24	150	Good	C	C	240 240	
239	Sweetaloy 17	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 67; Ni, 22; Cr, 10; Mn, 0.50; Si, 0.50; C, < 0.25	7.95	2550- 2600	1.05			Cast	79	47	23	24	150	Good	C	C	241 241	
240	Sweetaloy 18	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 71; Cr, 28; Mn, 0.50; Si, 0.50; C, < 0.30	7.60	2500- 2600	0.61			Cast	50	35	2	3	170	Good	C	C	242 242	
241	Sweetaloy 19	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 45; Ni, 30; Cr, 18; Mn, 0.50; Si, 0.50; C, < 0.30	8	2600	0.61			Cast	64	41	7	7.8	165	Good	C	C	243 243	
242	Sweetaloy 20	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 45; Ni, 30; Cr, 18; Mn, 0.50; Si, 0.50; C, < 0.30	8	2625	0.61			Cast	62	48	4	3	170	Good	C	C	244 244	
243	Sweetaloy 21	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 65; Ni, 19; Cr, 15; Mn, 0.50; Si, 0.50; C, < 0.50	8.20	2600	0.61			Cast	70	60	3	2.5	200	Good	C	C	245 245	
244	Sweetaloy 22	Cooper Alloy Fdry. Co., Elizabeth, N. J.	Fe; 63; Cr, 26; Ni, 10; Mn, 0.50; Si, 0.50; C, < 0.50	8	2550- 2600	0.90			Cast	70	60	3	2.5	200	Good	C	C	246 246	
245	Tanttron	Bethlehem Fdry. & Mach. Co., Bethlehem, Pa.	Fe; 84.9; Si, 13.5; C, 1; Mn, 0.4; P, 0.18; S, 0.05	2400					Hard wire soft wire	140 100	85 60	3	45	260	Unmachinable	W	W	247 247	
246	Thermalloy B	Electro Alloys Co., Elkton, Ohio	Fe; Ni, 40; Cr, 20; Si, 1.5; Mn, 1.5; C, 0.40-0.60	7.90	2500	0.01			Annealed sheet	10	4	10	10	241	Good	W	W	248 248	
247	Toncan Iron	Republic Steel Corp., Massillon, Ohio	Fe; Cr, 0.40 min.; Mo, 0.05 min.; C	7.88	2750- 2800	0.74	0.18	0.11	Rolled bar Rolled sheet	45-55 48-58	30-40 32-40	35-40 56-75	80-80 30	242	Good	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	249 249	
248	Tophet C	Gilby Wire Co., Newark, N. J.	Fe; Ni, 60; Cr, 15; Fe, 15;	8.2	2400	0.76			Annealed sheet	85	35	60	25	165	Good	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	250 250	
249	U S S 12	Subsidiary Manufacturing Companies of Pittsburgh U. S. Steel Corp., New York, N. Y.	Fe; Cr, 12-15; Ni, 0.50 max.; Mn, 0.50 max.; C, < 0.1	7.8	2660	0.63	0.07	0.11	Annealed sheet	75	40	22	22	249	Good	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	251 251	
250	U S S 17	Amer. Sheet & Tin Plate Co., Pittsburgh, Pa.	Fe; Cr, 16-18; Ni, 0.50 max.; Mn, 0.50 max.; C, < 0.1	7.7	2600	0.61	0.07	0.11	Annealed sheet	85	35	60	25	249	Good	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	252 252	
251	U S S 18-8	Amer. Alloys Co., Bethlehem, Pa.	Fe; Cr, 16-20; Ni, 7-12; Mn, 0.4- 0.7; Mn, 0.5 max.; C, < 0.12	7.92	2570- 2600	0.89	0.05	0.12	Annealed sheet <sup>10</sup>	85	35	60	25	249	Good	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	253 253	
252	U S S 18-8 Stabilized	Illinois Steel Co., Chicago, Ill.	Fe; Cr, 22-28; Ni, 12-16;	7.92	2550- 2600	0.89	0.04	0.12	Annealed sheet	95	45	40	28	249	Good	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	254 254	
253	U S S 25-12	National Tube Co., Pittsburgh, Pa.	Fe; Cr, 16-20; Ni, 9-12; Mn, 0.4- 0.7; Mn, 0.5 max.; C, < 0.12	7.6	2575	0.56	0.06	0.11	Annealed sheet	85	50	15	28	249	Fair	B, DD, F, R, B, CR, D, HR, P, S, T, W	B, DD, F, R, B, CR, D, HR, P, S, T, W	255 255	
254	U S S 27	General Alloys Co., Boston, Mass.	Fe; Cr, 25-30; Ni, 0.50 max.; Mn, 0.5 max.; C, < 0.1	7.6	2575	0.01			Annealed sheet	65- 70	53- 56	2-5	4	249	Fair	R, W R, W	R, W R, W	256 256	
255	X-site	Michiana Products Corp., Michigan City Ind.	Fe; Ni, 37-39; Cr, 17-19	8.05	2650- 2705	0.70	0.04	0.14	Cast	70	40	5	6	180	Fair	D, F, R, W D, F, R, W	C, B, S C, B, S	257 257	
256	Zorite	Michiana Products Corp., Michigan City Ind.	Fe; Ni, 35; Cr, 15; C, 0.50 max.	7.90	2350- 2430	0.04	0.135	0.135	Cast	55	40	5	6	180	Fair	D, F, R, W D, F, R, W	C	258 258	
257	48 Alloy	Michiana Products Corp., Michigan City Ind.	Fe; Cr, 28; Ni, 8; C, 0.50 max.	7.88	0.92	0.030			Cast	65	1	1	1	65	Fair	D, W D, W	B, C, HR, S B, C, HR, S	259 259	
258	100 Alloy	Michiana Products Corp., Michigan City Ind.	Fe; Cr, 25; Ni, 12; C, 0.50 max.	7.87	2400- 2475	0.90	0.04	0.135	Cast	65	45	3.5	3	65	Fair	D, W D, W	B, C, HR, S B, C, HR, S	259 259	

## MODERN METALS

### Footnotes to data sheets

- <sup>1</sup> Physical properties can be varied by heat treatment.  
<sup>2</sup> Physical properties can be improved by cold working.  
<sup>3</sup> Use slow speed and heavy feed.  
<sup>4</sup> Also material can be supplied with free machining qualities.  
<sup>5</sup> Webert bars cast to shape.  
<sup>6</sup> In grey iron castings.  
<sup>7</sup> Good bearing qualities.  
<sup>8</sup> Nickel if desired.  
<sup>9</sup> Good before heat treatment, can only be ground after heat treatment.  
<sup>10</sup> Ultimate strength and yield point for strip material can be increased by cold working.  
<sup>11</sup> Before recommending an alloy for corrosion service, company prefers to know all details of service conditions.

**Licenses American Stainless Steel Co., Pittsburgh, Pa.** — Allegheny Steel Co., Braddock, Pa.; Bethlehem Steel Co., Bethlehem, Pa.; The Carpenter Steel Co., Reading, Pa.; Colonial Steel Co., Pittsburgh, Pa.; Columbia Tool Co., Chicago Heights, Ill.; Crucible Steel Co. of America, New York, N. Y.; Harry Dietrich & Sons, Philadelphia, Pa.; Duray Company, Pittsburgh, Pa.; Firth-Sterling Steel Co., McKeesport, Pa.; Halcomb Steel Co., New York, N. Y.; Heppenstall Co., Pittsburgh, Pa.; Jessop Steel Co., Washington, Pa.; Latrobe Electric Steel Co., New York, N. Y.; Ludlum Steel Co., Watervliet, N. Y.; Midvale Co., Philadelphia, Pa.; Republic Steel Corp., Massillon, Ohio; Simonds Saw & Steel Co., Lockport, N. Y.; Union Electric Steel Corp., Pittsburgh, Pa.; Universal Steel Co., Bridgeville, Pa.; Vanadium-Alloy Steel Co., Latrobe, Pa.; Vulcan Crucible Steel Co., Aliquippa, Pa.; Brighton Electric Steel Casting Co., Beaver Falls, Pa.; Chapman Valve Mfg. Co., Indian Orchard, Mass.; Chrome Alloy Products, Inc., Philadelphia, Pa.; Cooper Alloy Foundry Co., Elizabeth, N. J.; Empire Steel Casting Co., Reading, Pa.; Hartford Electric Steel Corp., Hartford, Conn.; Lebanon Steel Foundry, Lebanon, Pa.; Michiana Products Corp., Michigan City, Ind.; Stryer Steel Casting Co., Milwaukee, Wis.; Union Spring & Mfg. Co., New Kensington, Pa.; Wehr Steel Co., Milwaukee, Wis.

**Licenses of Chemical Foundation, New York, N. Y.** — Bethlehem Steel Co., Bethlehem, Pa.; Allegheny Steel Co., Braddock, Pa.; Electro Metallurgical Co., New York City; Republic Steel Corp., Youngstown, Ohio; Jessop Steel Co., Washington, Pa.; Universal Steel Co., Bridgeville, Pa.; Colonial Steel Co., Reading, Pa.; Crucible Steel Co., of America, New York City; Union Electric Steel Corp., Pittsburgh, Pa.; Riverton Steel Co., Pittsburgh, Pa.; Midvale Co., Philadelphia, Pa.; Ludlum Steel Co., Watervliet, New York; Simonds Saw and Steel Co., Fitchburg, Mass.; Rustless Iron Corp. of America, New York City; Onondaga Steel Co., Onondaga County, New York; Latrobe Electric Steel Co., New York City; Babcock and Wilcox Co., Beaver Falls, Pa.; Colonial Steel Co., Pittsburgh,

Pa.; Illinois Steel Co., Chicago, Ill.; Forging and Casting Corp., Detroit, Mich.; Michiana Products Corp., Michigan City, Ind.; Michigan Steel Casting Co., Detroit, Mich.; Ohio Steel Foundry Co., Lima, Ohio; Monarch Foundry Co., Stockton, Calif.; Weirton Steel Co., Weirton, Hancock County, W. Va.; Symington Company, Rochester, New York; Wheeling Steel Corp., Wheeling, W. Va.; Ingersoll Steel & Disc Co., New Castle, Ind.; General Alloys Co., Boston, Mass.; West Steel Casting Co., Cleveland, Ohio; Lebanon Steel Foundry, Lebanon, Pa.; Duraloy Co., Pittsburgh, Pa.; Driver-Harris Co., Harrison, N. J.; Enterprise Foundry Co., San Francisco, Calif.; Milwaukee Steel Foundry Co., Milwaukee, Wis.; Taylor-Wharton Iron and Steel Co., High Bridge, N. J.; Stryer Steel Casting Co., Milwaukee, Wis.; Copper Alloy Foundry, Elizabeth, N. J.; National Forge and Ordnance Co., Irving, Warren County, Pa.; Whitehead Metal Products Co., New York, N. Y.; Crucible Steel Casting Co., Cleveland, Ohio; Timken Steel & Tube Co., Canton, O.; Duncan Foundry and Machine Works, Alton, Ill.; Warman Steel Casting Co., Los Angeles, Calif.; Crane Company, Chicago, Ill.

**Licenses of Krupp Nitrosta Co., New York** — Aeme Steel Co.; American Forge Co.; Babcock & Wilcox Tube Co.; Bacon & Matheson Forge Co.; Baldwin Anchor, Chain & Forge Co.; Crucible Steel Co. of America; Detroit Seamless Steel Tubes Co.; Henry Disston & Sons; Driver-Harris Co.; Finkl & Sons Co.; Firth-Sterling Steel Co.; Globe Steel Tubes Co.; Griffin Manufacturing Co.; Heppenstall Co.; Ludlum Steel Co.; Lukens Steel Co.; American Steel & Wire Co.; Newton Steel Co.; Ohio Seamless Tube Co.; Pennsylvania Forge Corp.; Pittsburgh Steel Co.; Republic Steel Corp.; Sharon Steel Hoop Co.; Spang-Chalfant & Co.; Standley Works; Summerill Tubing Co.; Union Drawn Steel Co.; Wallingford Steel Co.; Calorizing Co.; Chapman Valve Mfg. Co.; Chrome Alloy Products; Cleveland Alloy Products Co.; Duriron Co.; Electric Steel Foundry Co.; General Alloys Co.; Michiana Products Corp.; Millbury Steel Fdry. Co.; Milwaukee Steel Foundry Co.; Monarch Foundry Co.; Pacific Foundry Co., Ltd.; Shawinigan Stainless Steel & Alloys, Ltd.; St. Joseph Elec. Steel Castings Co.; Standard Alloy Co.; Wm. J. Sweet Foundry Co.; Symington Co.; Taylor-Wharton Iron & Steel Co.; Texas Elec. Steel Castings Co.; Warman Steel Casting Co., Ltd.; Washington Iron Works; West Steel Casting Co.

**Licenses of Mechanite Metal Corp., Chattanooga, Tenn.** — H. W. Butterworth & Sons Co.; Bethpage, Pa.; Trenton Malleable Iron Co.; Trenton, N. J.; Heppenstall Co.; Edry Co.; Detroit, Mich.; Hamilton Edry & Machine Co., Hamilton, Ohio; Koehring Co., Milwaukee, Wis.; Dayton Malleable Iron Co., Dayton, Ohio; Fulton Edry & Machine Co.; Farrel-Birmingham Co., Ansonia, Conn.; Rosedale Edry & Machine Co., Pittsburgh, Pa.; Dodge Manufacturing Co., Toronto, Canada; Ross-Meehan Foundries Co., Chattanooga, Tenn.; Greenlee Foundry Co., Chicago, Ill.; Kinney Iron Works, Los Angeles, Calif.; West Coast Mechanite Metal Corp., Los Angeles, Calif.; Griffen Wheel Co., Chicago, Ill.; Banner Iron Works, St. Louis, Mo.; American Laundry Machine Co., Rochester, N. Y.

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**HYDROGEN SULPHIDE:** Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Antimonial Lead, 20; Chemical Lead, 3; Chromium Iron, 93; Circle L 10, 99; Circle L 11, 100; Circle L 12, 101; Circle L 14, 103; Circle L 15, 104; Circle L 31, 109; Cyclops 17 Metal, 122; Defrust, 124; Defrust, Spec., 125; Duriron, 132; Duro Gloss, 133; Empire 30, 140; Hastelloy A, 158; Hastelloy C, 31; Heat Resisting St. 5, 159; Highgloss C, 160; Highgloss DD, 161; Hy-Glo, 163; Lesco 18-8, 164; Lesco 18-8S, 165; Lesco 21-12, 166; Lesco 25-20, 167; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Meehanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 25-20, 179; Midvaloy 25-20, 180; Midvaloy 25-20, 181; Midvaloy 25-20, 182; Midvaloy 25-20, 183; Misco C, 184; Misco HN, 185; Monel Metal, 37; Nevastain A, 186; Nevastain KA2, 187; Nevastain RA, 188; Nevastain KA2, 199; Regular SS, 210; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron 16, 229; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Standard Misco, 235; Stellite 1, 58; Stellite 6, 59; Stellite 12, 60; Sterling Nirosta, 236; Sterling Stainless St. F. C., 237; Sweetaloy, 239; Tantalum, 11; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

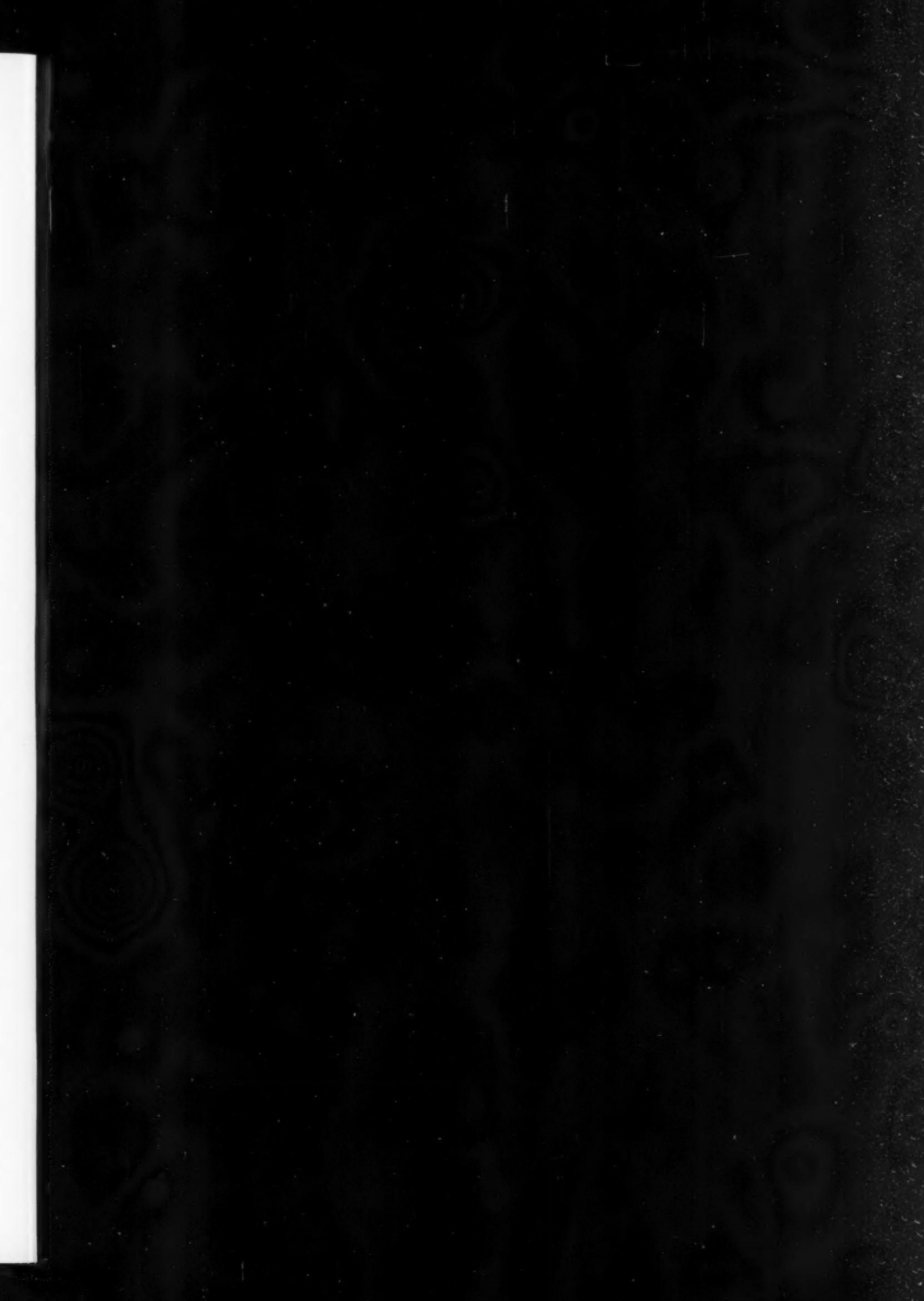
**OXIDES OF NITROGEN:** Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Chromax, 89; Circle L 31, 109; Chromium Iron, 93; Duro Gloss C2, 133; Duriron, 132; Defheat, 123; Defrust, 124; Defrust, Spec., 125; Empire 30, 140; Hastelloy C, 31; Highgloss C, 160; Highgloss DD, 161; Hy-Glo, 163; HR-5M, 162; Lesco 18-8, 164; Lesco 18-8S, 165; Lesco 21-12, 166; Lesco 25-20, 167; H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Misco C, 184; Meehanite Metal, 174; Ni-chrome, 190; Ni-chrome IV, 39; Ni-Resist, 194; Ni-Resist Copper Free, 195; Nirosta, 199; Rezistal 2C, 215; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron 16, 229; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Standard Misco, 235; Stellite 1, 58; Stellite 6, 59; Stellite 12, 60; Sterling Nirosta, 236; Sterling Stainless St. F. C., 237; Sweetaloy, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

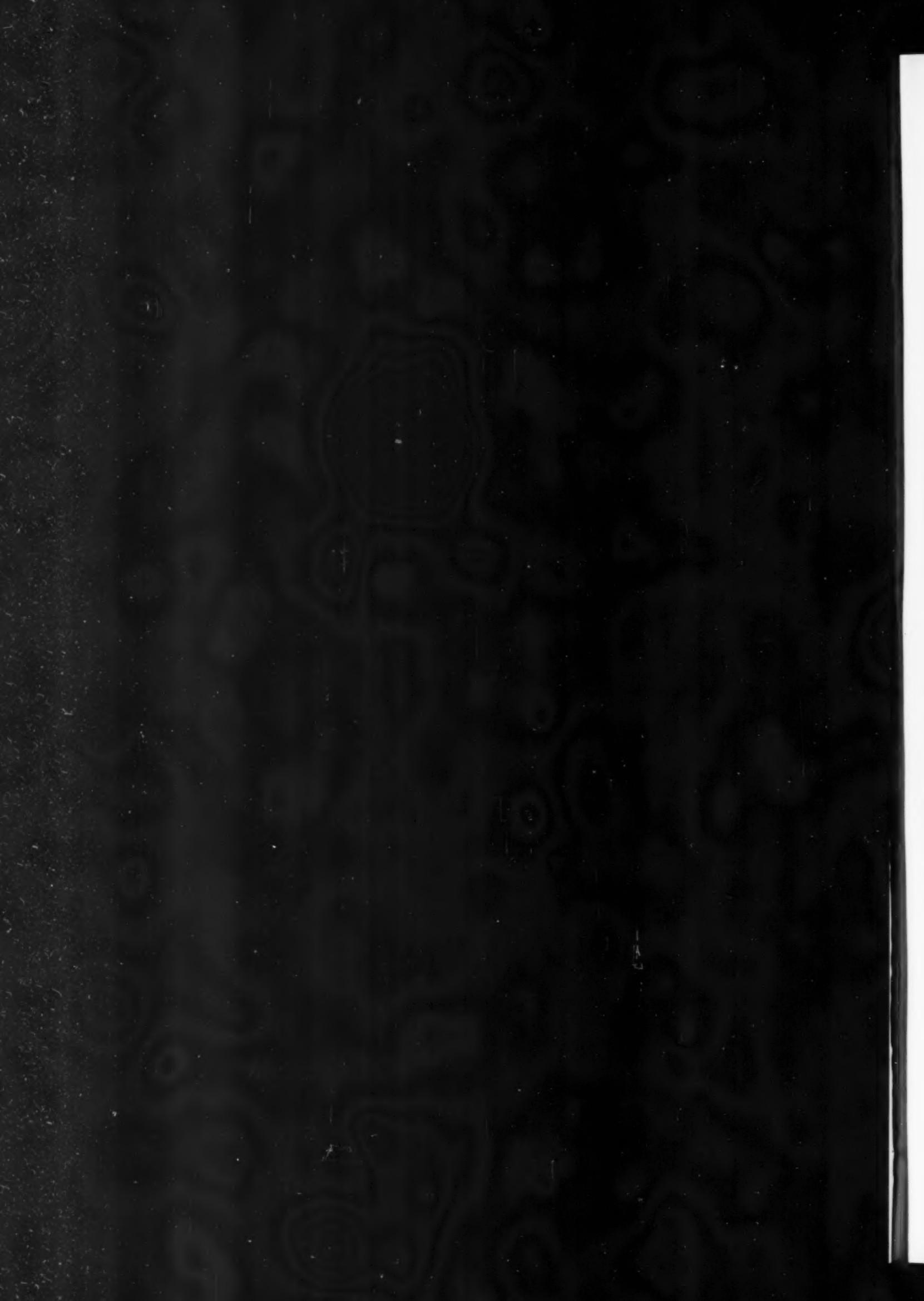
**OXIDIZING ATMOSPHERE:** Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Chemical Lead, 3; Chromax, 89; Chromium Iron, 93; Circle L 11, 100; Circle L 12, 101; Circle L 14, 103; Circle L 15, 104; Circle L 31, 109; Circle L 32, 110; Defheat, 123; Defrust, 124; Defrust, Spec., 125; Defstain, 126; Duriron, 132; Durco, 130; Durimet, 131; Durworn, 132; Duro Gloss C2, 133; Duro Gloss C3, 134; Empire 30, 140; Fahrte N-2, 152; Hastelloy C 31; Heat Resisting St. 5, 159; Highgloss C, 160; Highgloss DD, 161; Hy-Glo, 163; Lesco 18-8, 164; Lesco 21-12, 166; Lesco 25-20, 167; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Meehanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 25-20, 179; Midvaloy 25-20, 180; Misco C, 184; Monel Metal, 37; Nevastain A, 186; Nevastain KA2, 187; Nevastain RA, 188; Nickel Chrome Cast Iron, 191; Ni-hard 193; Ni-Resist, 194; Ni-Resist Copper Free, 195; Nirosta KA2, 199; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Standard Misco, 235; Sweetaloy 17, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

**REDUCING ATMOSPHERE:** Advance, 13; Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Aluminum 28, 1; Antimonial Lead, 20; Chemical Lead, 3; Chromax, 89; Chromium Iron, 93; Circle L 15, 104; Circle L 31, 109; Circle L 32, 110; Defheat, 123; Defrust, 124; Defstain, 126; Durimet, 131; Duriron, 132; Duro Gloss C2, 133; Duro Gloss C3, 134; Empire 30, 140; Fahrte N-2, 152; Hastelloy C 31; Heat Resisting St. 5, 159; Highgloss C, 160; Highgloss DD, 161; Hy-Glo, 163; Lesco 18-8, 164; Lesco 21-12, 166; Lesco 25-20, 167; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Meehanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 25-20, 179; Midvaloy 25-20, 180; Misco C, 184; Monel Metal, 37; Nevastain A, 186; Nevastain KA2, 187; Nevastain RA, 188; Ni-Resist, 194; Nirosta KA2, 199; P-M-G Metal, 52; Regular SS, 210; Rezistal 3, 211; Rezistal 7, 213; Rezistal 2C, 215; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron 18, 229; Stainless Iron 24, 231; Stainless Steel, 234; Standard Misco, 235; Sweetaloy 17, 239; Tantalum, 11; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

**SULPHUR DIOXIDE:** Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Allegheny 33, 65; Allegheny 44, 66; Allegheny 55, 67; Allegheny 66, 68; Allegheny Metal, 69; Antimonial Lead, 20; Chemical Lead, 3; Chromium Iron, 93; Circle L 15, 104; Circle L 31, 109; Circle L 32, 110; Defheat, 123; Defrst, 124; Defstain, 126; Durimet, 131; Duriron, 132; Duro Gloss C2, 133; Duro Gloss C3, 134; Empire 30, 140; Fahrte N-2, 152; Hastelloy C 31; Heat Resisting St. 5, 159; Highgloss C, 160; Highgloss DD, 161; Hy-Glo, 163; Lesco 18-8, 164; Lesco 21-12, 166; Lesco 25-20, 167; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Meehanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 25-20, 179; Midvaloy 25-20, 180; Misco C, 184; Monel Metal, 37; Nevastain A, 186; Nevastain KA2, 187; Nevastain RA, 188; Ni-Resist, 194; Nirosta KA2, 199; P-M-G Metal, 52; Regular SS, 210; Rezistal 3, 211; Rezistal 7, 213; Rezistal 2C, 215; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Standard Misco, 235; Sweetaloy 17, 239; Tantalum, 11; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.

**SULPHUR TRIOXIDE:** Aluminum 28, 1; Alclad, 14; Aluminum 38, 17; Antimonial Lead, 20; Chemical Lead, 3; Duray Company, 127; Durimet, 131; Duriron, 132; Duro Gloss C2, 133; Duro Gloss C3, 134; Empire 30, 140; Hastelloy C 31; Highgloss C, 160; Highgloss DD, 161; Hy-Glo, 163; Lesco 18-8, 164; Lesco 21-12, 166; Lesco 25-20, 167; Lesco H, 168; Lesco HH, 169; Lesco L, 170; Lesco M, 171; Meehanite Metal, 174; Midvaloy 18-8, 176; Midvaloy 25-10, 177; Midvaloy 25-20, 178; Midvaloy 25-20, 179; Midvaloy 25-20, 180; Misco C, 184; Monel Metal, 37; Nevastain A, 186; Nevastain KA2, 187; Nevastain RA, 188; Ni-Resist, 194; Rezistal 3, 211; Rezistal 4, 212; Rezistal 7, 213; Rezistal KA2, 216; Rezistal KA2 Mo, 217; Stainless Iron, 226; Stainless Iron 18, 230; Stainless Iron 24, 231; Stainless Steel, 234; Standard Misco, 235; Sweetaloy 17, 239; Tantalum, 11; Tophet A, 63; Tophet C, 248; USS 12, 249; USS 17, 250; USS 18-8, 251; USS 18-8 Stabilized, 252; USS 25-12, 253; USS 27, 254.





# MODERN MATERIALS



*News of Progress in Corrosion Resistance*

CHEM. & MET.

SEPTEMBER, 1932

## Hydrogenation Made Possible By New Alloys

High Temperatures and Pressures Combined to Effect New Petroleum Process

WITHOUT the use of special corrosion- and heat-resistant alloys, it would have been impossible to have carried the process of petroleum hydrogenation to its present stage of development. This statement was recently made by R. T. Haslam, vice-president of the Standard Oil Development Co. at the time the plant at Bayway, N. J., was visited by a group of magazine and newspaper representatives. As was pointed out at the time this process was first announced in this country in *Chem. & Met.* (Vol. 36, No. 6, June, 1929), the plant at Bayway called for the largest ingot forgings of alloy steel that had ever been fabricated in the United States. These reaction chambers, made by the Midvale Co., are 40 ft. in height, 3 ft. 6 in. in inside diameter, and with wall thicknesses of 7 in. They must operate at pressures of 3,600 lb. per square inch with temperatures up to 1,000 deg. F.

From a chemical engineering standpoint, one of the most severe requirements of metal in the hydrogenation process is in the production of hydrogen which is made at Bayway by reforming refinery gases at a temperature of approximately 1,800 deg. F. This operation is effected in high chromium-nickel alloy steel tubes suspended vertically in a gas-fired furnace. Although in continuous service for more than 20 months, there has not been a single tube failure in the hydrogen plant.

The presence of sulphur in the cracking coil gases is one of the sources of difficulty, due not only to corrosion but also to the deposition of elemental sulphur during subsequent stages in the process. Accordingly, at Bayway, a Koppers purification plant has been installed which removes the sulphur by scrubbing the gas with soda ash solution. This step is not necessary, however, at the Baton Rouge, La., plant (see article by Marion Boyer, *Chem. & Met.*, December, 1930) where natural gas is used as the source of hydrogen.

Chrome-nickel steel tubes are used in the gas-fired coil in which the oil-hydrogen mixture is heated to about 1,000 deg. prior



Looking up at the largest ingot forgings of alloy steel ever fabricated in the United States. They stand 40 ft. high and are 3.5 ft. in diameter, with walls 7 in. thick.

to the reaction in the presence of the catalyst. The use of this alloy in the hot parts of the high pressure equipment has eliminated hydrogen embrittlement and hydrogen sulphide corrosion which would have been experienced with ordinary steel.

An unusual corrosion problem was encountered in the Baton Rouge plant, however, due to a manufacturer's error in failing to follow the specifications which the designers had set for a certain piece of equipment. In this plant the carbon dioxide is removed from the hydrogen by means of triethanolamine, and the designers specified that steel tubes should be used in the acticifer heating coil. By mistake, admiralty tubing was first employed and shortly after the plant was in operation, it was noted that the solution had turned blue due, of course, to the action of the amine on the copper. Shortly thereafter the coil failed because of corrosion, but after tubes of proper metal were substituted, no further trouble was encountered. In connection with this use of triethanolamine, however, it is interesting to note that the saturated solution (so-called foul liquor) may be corrosive not only because of the amine or ammonia content, but also because of the dissolved carbon dioxide and hydrogen sulphide. Fortunately, alloys are readily available which will resist this "double-barreled" corrosion attack.

## Alloys Progress Bright Spot in Business Gloom

J. A. Mathews Commends Advances; Warns Against Incautious Use of Data

IN a statement to *Chem. & Met.*, John A. Mathews, one of the foremost figures in steel technology and vice-president of the Crucible Steel Co., finds that the manufacture and utilization of corrosion resisting steels has been one of the most gratifying recent industrial advances. The progress has been an unusually broad one, extending into every branch of research. As a practical matter, he points out, published data can be a boon or a bane; like fire they must be correctly applied. His full statement follows:

"Progress in the manufacture and utilization of corrosion resisting steels has been the one bright spot 'amid the encircling gloom' of business during the last three years. Intensive research on the properties, fields of usefulness, methods of manufacture and of fabrication has been successful and the sale of these products has developed into a considerable volume in industries that were not looked upon as potential customers only a few years ago. Apparently the seriousness of the need for just those qualities that the corrosion resisting steels provide was not appreciated by industry itself until long after the materials were available."

"We have had to learn an entirely new branch of metallurgy and as is the case with many developments we have had to go through a period of mis-application and mis-use." Dr. Mathews then warns against the incautious application of corrosion tables by chemical engineers.

"The presentation of tabular data about their physical or chemical properties may be very useful or very disastrous, depending upon the judgment and discrimination of the one using the data. We have not yet reached a point where the last word upon an individual problem may be found in tables. These must of necessity be very general, and the experience of those who have spent years in the study and development of corrosion resistant steels should be

sought before any serious project involving their use is contemplated.

"Frequently specific investigations must be made to answer the requirements of an unusual industrial application before any recommendations can be made even by the most expert in the field of corrosion problems. Laboratory tests must frequently be checked by tests under operating conditions because it may be impossible to duplicate in the laboratory all the conditions of temperature, pressure, erosion and corrosion, concentration of principal ingredients and of impurities. Frequently impurities, perhaps those whose existence is overlooked, may exert a profound effect on final success or failure.

"We have every reason for encouragement in the great progress that has occurred and manufacturing chemists, makers of food and dairy products, architects, as well as hotel, restaurant and hospital supply firms, are already under a great obligation to the metallurgists who have made these extremely useful alloys possible."

### Silver, Low Priced, Renews Its Appeal to Industry

SILVER was formerly widely used in chemical operations such as the manufacture of pharmaceuticals and foodstuffs. In the past decade its use has declined, however, both because of price and the development of many other useful metals. With the price down at record low at present, its industrial uses have grown very rapidly again, especially in England and on the Continent. In this country recent installations have been confined to foodstuffs, pharmaceuticals, and dye plants.

It is made commercially in sheets of all thicknesses, tubes, wire and castings. Acetic acid has been frequently combatted with silver, both in the condensation equipment in acid manufacture and solvent recovery in acetate rayon. The distillation of phenol, in especially pure grades, has also called silver into service. Condenser coils made of silver have long been used in certain chlorination processes, particularly in the fine chemical industry. An ethyl acetate plant with considerable silver lined equipment was reported in the technical press some years ago but the industry as a whole has not followed this trend.

Silver sheets rolled onto copper or other base metals, sometimes known as *double*, is used to reduce the cost of some apparatus. Pipe lines are made by drawing a tube of base metal over a seamless tube of silver, the combination being sufficiently strong to withstand high vacuum without separation. Coils for heating corrosive liquors are made in the same way, but with the silver outside.

Manufacture of fine-silver equipment is being done in the United States by Handy & Harman, New York City, and more recently by the American Platinum Works, Newark, N. J.

### Further Information

on developments mentioned in this section will be gladly supplied on request by the editorial staff of *Chem. & Met.* Naturally information on many others, that could not appear through restrictions of space, is likewise available.

### Phosphate Rock Mills Employ Rubber Linings

IN THE phosphoric acid plant of the Consolidated Mining & Smelting Co. at Trail, B. C., phosphate rock is ground wet in rubber-lined tube mills, using weak phosphoric acid as the grinding solution. The mills are constructed of iron and steel with all interior surfaces rubber coated by the Thermoprene process of the B. F. Goodrich Rubber Co. After being sandblasted, the surfaces are coated with Vulcalock cement over which a high quality of 97 per cent gum rubber,  $\frac{1}{8}$  to  $\frac{1}{4}$  in. thick, is applied by hand. Bonding and development of the elasticity and tensile strength of the rubber follow a carefully controlled steam cure. Longitudinal wood strips are applied inside the rubber, and upon these a final lining of silica blocks.

### Unsuspected Contamination Accelerated Tank Corrosion

IN an unusual case of corrosion recently reported to *Chem. & Met.*, an unsuspected source of contamination in a sulphuric-acid-containing solution proved to be the undoing of an otherwise resistant lead-lined tank. Three lead-lined tanks of equal capacity were operating side by side in identical service. But while the two outer tanks had given an entirely satisfactory performance for a period of years, the middle tank had to be relined every few months. When the chemical engineer who was called in on the problem had examined the set-up, he discovered that the lead feed line of the middle tank contained a nickel-alloy valve, whereas the other tanks were equipped with hard-lead valves. Once he had substituted lead for the offending part, no further difficulty was experienced.

The explanation of the phenomenon lay in the electrolytic couple of lead and nickel alloy which was formed when the valve was inserted in the line. Because it is higher in the electromotive series than lead, a minute quantity of nickel went continuously into solution, and although it was insufficient to appear in the product, it was more than enough to upset the resistance of the lead to the concentration and temperature of acid used.

## Service Uses of Enamel Governed By Requirements

**Experience of the Equipment Manufacturer Shows the Essential Need for Specifying Quality**

IN RECENT years, the manufacturers of glass-lined equipment have made it a point to insist that customers furnish them with complete information about the chemical conditions to be met in the plant, in order that before the equipment is constructed, they can specify the grade of enamel best suited to the particular purpose. Glass enamels, as furnished by the Pfaudler Co., for example, are essentially complex boro-silicates, the basic raw materials being silica and borax. Their color is imparted by certain oxides (such as cobalt which yields a blue) but which are entirely insoluble after fusion, and therefore cannot impart color to a solution which comes in contact with them. The enamels are compounded, fused at high temperatures and reduced to a fine powder (frit) as separate operations preliminary to their application to steel or cast iron.

Application of glass enamels may be made by either the wet or the dry process. The former are applied by spraying before the tank enters the enameling furnace. The surface which is to be enameled has previously been sand-blasted so as to remove scale and to present a somewhat roughened surface that will facilitate adherence of the enamel. The tank then enters the enameling furnace and is subjected to temperatures of approximately 1,850 deg. F. The powdered enamel melts and fuses, yielding a smooth vitrified outer surface and a firm bond to the metal, since a chemical combination occurs at the surface of the contact. The first application constitutes a ground coat, and one or more finish coats are added by the same method. These wet process enamels can be applied to either open or closed, all-welded units, but only to steel; never to cast iron.

The hot dust enamels, which are the dry process coatings, are applied to steel or cast iron shapes immediately after removal from the furnace while the surface is still at peak temperature. It is physically impossible to coat by this method, an individual piece larger than about 500 gal., and the enameling furnace has been constructed with this limitation in mind. The method of application obviously limits the design to individual open pieces. Hence all-welded closed pieces cannot be lined with these enamels and the covers must be clamped or bolted on.

The hot dust enamels are usually, but not always, specified for severe conditions, particularly those involving strong inorganic acids such as hydrochloric, nitric and sulphuric. The wet process enamels are usually specified for the less severe conditions met in the larger sizes of equipment.

## Cast Iron, Dressed Up With Nickel, Extends Service

**Corrosion Resistance, With Low Cost, Is Obtained by New Product, Nickel-Copper-Chrome**

A GOOD middle ground between the metals for severest service and those for ordinary use is being met by different low-alloy cast irons. A further modification is the higher-alloy Ni-Resist, in which the principal modifying material is up to 15 per cent of nickel, as the name suggests.

Low cost and resistance to growth and scaling, were the aims of the International Nickel Company in developing this material during the past few years. It was found that the addition of nickel to iron, above 2 per cent and up to 15 per cent showed a fairly rapid increase in corrosion resistance, decrease in magnetism, indicating austenitization, and increased hardness. Copper was then substituted for part of the nickel and up to 6 per cent increased resistance to specific chemicals and lowered its melting point, with consequent greater fluidity and casting properties.

Manganese was then added to counteract low-temperature changes. The tensile properties and hardness still remained to be brought up. The addition of chromium in increasing amounts readily achieved this, but it was decided to limit it to two or three per cent, which gave around 150 Brinell. However, the composition can be hardened, just like ordinary cast iron, by chilling. The final optimum composition was 14 per cent nickel, 6 of copper, 2-3 of chromium, and carbon and silicon as in ordinary cast iron.

Physically, the new material excels in several respects. Its coefficient of thermal expansion is greater than plain cast iron and similar to that of bronze, but its growth and warpage are non-existent in cases where cast iron changes considerably. In welding, for which the material is well suited, the use of arc or acetylene and a filler rod of the same composition is recommended.

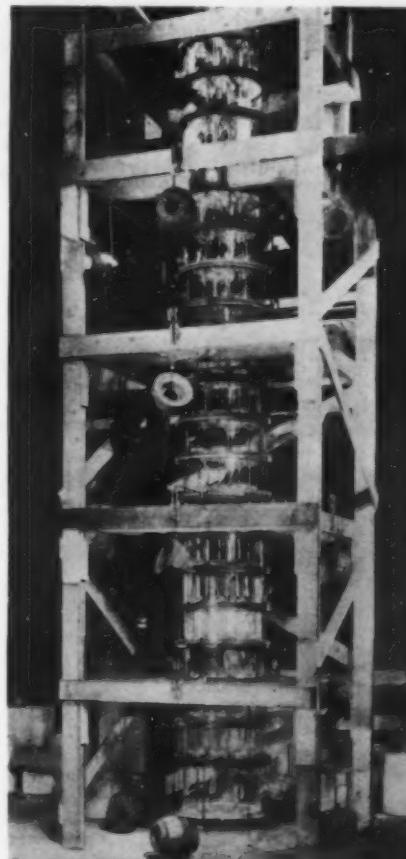
Chemically, it cannot compete for many uses with its more expensive prototype, the high-alloy steels, but in most instances it is much superior to plain cast iron. Its corrosion product is a rough deposit which forms slowly and evenly. Its heat resistance exceeds that of cast iron but again falls below the chrome-nickel steels.

It has seen extensive service in an increasing number of oil refineries for crude oil, sludge, caustic lines and the like, and in various valve and pump fittings. Similarly, it has been used in typical castings of the sugar, paper and food industries. Pumps and propellers for sea-water service are performing creditably with Ni-Resist and in the heat resisting field it is used in glass rolls, glass annealing furnaces and enameling racks.

Another casting alloy, comparable to chilled or white cast iron, contains 2.5 to 6.0 per cent of nickel and 0.5 to 1.5 of chromium. It is called Ni-Hard and has a martensitic structure. Its particular advantage is resistance to wear. In pulverizer arms and cement-mill rolls and liners it has shown six times longer wear than plain chilled iron.

## Chrome-Nickel Alloy Named Nicraluminum

WORKING for light, structural strength, and not for specific corrosion resistance, as in the case of the chrome-nickel steels, Victor Hybinette, of the Nicraluminum Company, Jackson, Mich., has announced a new aluminum alloy which differs from the older strong composition in containing little copper. Instead the aluminum is alloyed with a mixture of nickel and chromium which in the sheet metal imparts a high luster and ductility. Extruded and structural sections recently made, showed a yield point of 60,000 lb., an ultimate strength of 70,000 lb., with 15 per cent elongation and high elasticity.



**WATCH THE DISTILLATION**

This glass tower, 24-in. in diameter, built by Corning Glass Co. for a commercial distillation process.

## Improved Cast Iron Widens Uses for Corrosion Service

**New Firm, Flawless Product Withstands Sulphuric Acid Better Than Untreated Gray Cast Iron**

BY metallurgical experiment, the Meehanite Metal Corp., has taken advantage of the possibility of reducing the graphitic particles in ordinary cast iron and producing a firm, flawless product that eliminates some of the former's shortcomings. This is achieved principally by a dispersion of all carbides over the amount necessary for pearlite into highly diffused graphite.

Up to 1,750 deg. F., Meehanite shows no reversal of volume changes and up to this temperature does not show any growth under repeated heating and cooling. In this respect, tests showed it to be superior to even semi-steel. It resists very dilute hydrochloric, any strength of acetic acid, soda and potash, and medium dilute and concentrated sulphuric acid. In a contact sulphuric acid plant, pumps of Meehanite lasted from eight months to two years with different strengths of acids, against one to six weeks for cast iron. It was also used in the valves and pipe lines. In this service a temperature of 200 deg. F. was usual.

## Resin Effect and Lacquer Permeability Are Studied

BECAUSE the increased use of nitrocellulose lacquers as protective coatings has created a demand for information on the effect of resins and plasticizers on their moisture and water permeability, the Hercules Powder Company has instituted a series of studies at its experiment station. Among the resins tested, special forms of alkyd and phenolic resins were foremost in preventing moisture permeability. Among the plasticizers and oils, the latter, especially linseed oil, were far ahead of the former, among which a complex adipate excelled.

## Hard Copper Pipe Used To Convey Paper Stock

BY use of a special fitting which strengthens the joint, hard copper piping has been introduced to several process industries by the Mueller Bronze Co., Port Huron, Mich. Thus it is being used in stock lines for conveying bleached as well as unbleached pulp, the joint allowing a smooth uninterrupted flow. Because of the hardness of the alloy, the tubing can be made light and thin.

## "Cannonball" Corrosion Presents Unsolved Problem

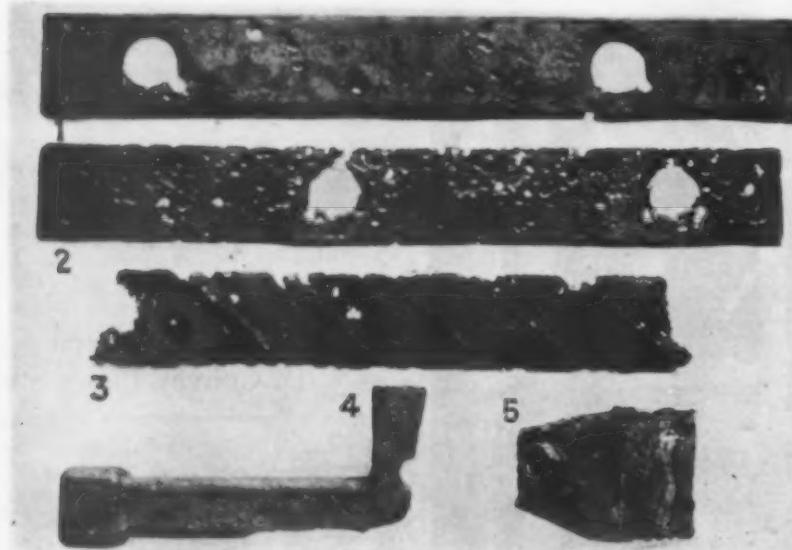
### Unusual Hemispherical Pitting of Steel in Oil Stills Difficult to Explain Satisfactorily

IN an informal discussion of the vagaries of corrosion which took place before the Petroleum Division of the A.C.S. at the meeting in New Orleans, Dr. H. M. Weir, of the process division of the Atlantic Refining Co., described a peculiar type of pitting which, for want of a better name, might be termed "cannonball corrosion." Specimens of metal taken from pipe stills that had been running Mid-Continent and West Texas crudes over a period of three or four years, showed that the corrosion had taken the form of almost perfect hemispherical pits which were as much as  $\frac{1}{2}$  to  $\frac{1}{4}$  in. deep in most cases. From the position of these pits on both horizontal and vertical surfaces, it was obvious that erosion had nothing to do with the phenomenon. Lacking other explanation, Dr. Weir stated that "we ascribed the type of corrosion shown by these samples to sulphur compounds, but we are quite at a loss to explain why such a large proportion of the corroded spots on the straight pieces were hollowed out in the form of portions of spheres."

The specimens shown in the accompanying photograph were taken from a section where the temperature of the liquid and vapor averaged around 775 deg. F. Samples 1, 2, and 3 were of sheet steel of 0.10 to 0.15 carbon content, and 4 and 5 are gray iron castings. Sample 2 gives the best idea of the hemispherical nature of the pits. Sample 3 shows the effect of corrosion at the welds which were at an angle of 45 deg. with the length of the pieces. The welded pieces had been completely loosened from this particular sample leaving only the ridge of the welds to indicate where the pieces were joined.

The castings are of interest because of the outline of the hex nut etched on Sample 4 and the erosion of the hex nut in Sample 5. This was characteristic in that corrosion around the nut was always smaller next to the piece on which it seats than it was at the top of the nut.

Dr. Weir also pointed out that aqua ammonia had been used in these stills at a rate of about 17 lb. of pure ammonia per 1,000 bbl. of crude oil. This was done to prevent corrosion due to acid formed by the hydrolysis of salts in the wet crude oil. However, this acid corrosion occurs normally at much lower temperatures than that to which these pieces were exposed. If *Chem. & Met.* readers can offer a possible explanation for this type of corrosion, or if similar experience has been noted in other plants, Dr. Weir would welcome this information. The correspondence columns of this magazine are open for discussion of such unusual problems.



SPECIMENS OF "CANNON BALL" CORROSION

Peculiar hemispherical pitting of metal first noted in petroleum stills. Specimens, 1, 2, and 3 are sheet steel; 4 and 5 are gray iron castings.

## Seamless Technique Overcomes Strains in Tubular Equipment

### Large Sizes Available for Use in Severe Service — Only Higher Grades of Steel Can Be Utilized

INSIDE diameters of up to 30 $\frac{1}{2}$  in. are being attained by a German process for tubular steel which is being represented in this country by the Seamless Steel Equipment Corporation, New York. In this "pressed and drawn" process the forged billet is cupped in a powerful hydraulic press when at white heat. The cup-shaped billet is next placed on the mandrel of a horizontal drawing press and then pressed and drawn through a series of dies until the desired length and thickness is obtained. Ingots weighing 20 tons have been formed in this way.

Only the higher grades of steel, such as the basic open-hearth and alloyed steels, are suitable for this process. However, the products are necessarily equipped for severe service, both because of corrosion resistance due to use of special steels and lack of seams, and because they will withstand high pressure.

## Iron Oxide and Sand Coat Guard Against Iron Rust

TAKING advantage of a domestic ore that contains a suitable agglomerate of ferric oxide, silica, and alumina, the Eastern Mabelite Corp., New York, produces a protective coating for use on metals. The vehicle of "Mabelite" may be any normal oil paint, and tests indicate that the mineral content affords abnormal protection against atmospheric conditions, mild solutions of acids and alkalis, and brines. The silica content furthermore protects it from abrasion. In practice it has been successfully applied to metal pipe lines, tanks, and concrete.

## Illiium Used in Sulphur Burners Resists Fumes

AFTER it had been tried successfully in instruments, the Burgess-Parr Company next adapted Illium to pumps for mine water where they excelled all previous service. Since then it has been used increasingly in especially severe types of corrosion. A spindle revolving at 20,000 r.p.m. is persulphuric and in acetic acid, showed no wear long after similar steel and gold-plated spindles had been worn away. Especially notable is the fact that it has been used in phosphate plants in the form of pumps and smaller equipment. In paper plants it is being used for pyrometer tubes in the sulphur burners.

## Synthetic Drying Oil Introduced by the DuPont Company

**Mono- and Divinylacetylene Yield Products That Are Resistant to Oils, Solvents, Corrosives**

FOLLOWING several years of investigation into the production of a rubber-like material which would have mechanical properties similar to rubber, but superior resistance to the action of petroleum derivatives, E. I. duPont de Nemours & Co., Wilmington, Del., has announced the development of two materials resulting from the investigation, one a plastic of rubber-like characteristics known as DuPrene, and the other a spontaneously polymerizable, synthetic drying oil, the name for which has been abbreviated to S-D-O.

When acetylene is passed into an aqueous solution of cuprous and ammonium chlorides, two principal reactions take place, yielding mono- and divinylacetylene. The first of these is converted to chloroprene which on partial polymerization gives an extremely tough synthetic rubber which can be handled, compounded and worked by methods similar to those used with natural rubber. So tough is this material that it is necessary to add softeners during the process of manufacture. As it is supplied to users, DuPrene contains sufficient softener and antioxidant to insure its satisfactory working on ordinary rubber machinery. Applications of DuPrene in the industrial-chemical and chemical-engineering fields include gaskets, packing, valve and regulator diaphragms, and hose for conveying oils and solvents that swell and attack rubber. It is reported that resistance much superior to that of rubber is obtained at no sacrifice of the strength, toughness and elasticity of rubber.

It is likely that the second acetylene derivative, S-D-O, will find even wider application than DuPrene. When divinylacetylene is heated in the absence of air at a temperature of approximately 185 deg. F., it polymerizes further, passing through various stages of aggregation until it eventually gels. If the polymerization is stopped at the proper point, a non-volatile, viscous drying oil called S-D-O Base is obtained, and this is capable of further polymerization, even in the absence of air. Polymerization is considerably more rapid in the presence of light and air, because the formation of minute quantities of peroxides catalyzes the solidification. To prevent this further polymerization, the S-D-O Base may be dissolved in an aromatic solvent such as coal tar naphtha in which it is soluble in all proportions. Thereafter, if it is kept out of contact with light and air, polymerization is avoided until the solvent has been allowed to evaporate, as in the application of the material as a coating.

When the solution is applied to a surface properly prepared to receive it, it dries tack-



S-D-O COATING ON TANK CAR DOME

After three years' service with mixed acid the coating and underlying metal are still intact.

free in one to two hours and is fully hardened within 48 hours. The hard, transparent, amber-colored resin that results is insoluble in all solvents and combinations of solvents, including S-D-O itself, and is unattacked by corrosive agents with the sole exception of strongly oxidizing media such as hot, concentrated nitric and sulphuric acids and hydrogen peroxide. The film is penetrated but uninjured by hydrogen fluoride and hydrofluoric acid. It is darkened but unharmed by strong acids and alkalis. It is mildly light-sensitive, darkening on exposure, but returns to its original amber in the absence of direct light.

Various strengths of S-D-O dissolved in naphtha, containing in some cases small percentages of non-wrinking agents, are now available, together with a number of S-D-O paints which are said to have better adhesion to metals than the unpigmented products. These coatings may be applied to almost any surface except glass and enamel. Wood and concrete may be coated directly, metal requires roughening, as by sand-blasting. Additional coats must be applied before the previous coat has set up. S-D-O, being brittle, cannot be used where flexing is required or where rapid tem-

perature changes occur. It may be used to temperatures of 390 deg. F. in the unpigmented varieties, 480 deg. in the paints. It supplies a high degree of protection against water penetration and the action of solvents, acids and alkalis. Applied to concrete floors it reduces wear materially and prevents dusting.

## Bromine Plant Must Meet Corrosive Attack

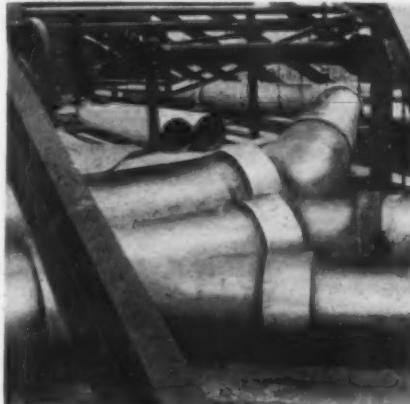
A UNIQUE feature of recent chemical engineering construction in the Southwest is a bromine (and iodine) plant built almost entirely of glass and glass-lined steel equipment. The bromine is recovered from a natural brine by distillation in seven stills all of Pfaudler acidproof glass-lined construction. These units, each of about 700 gal. capacity, are connected in series and placed one above another in a tower which exceeds 100 ft. in height. The stills are connected with Pyrex glass tubing and glass-lined steel pipe and fittings; the vapor lines which are packed with porcelain Raschig rings are 5-in. in diameter and the condensate lines are 2 in. in diameter. An ingenious method of jointing considered for this installation employs thin strips of tantalum metal wrapped around the glass pipe and clamped above and below the joints. It was claimed that this is the only metal that would permanently resist the attack of the wet chlorine gas which is used to liberate the bromine in the brine. Operating pressure in the stills is said to be about 20 lb. per square inch although the system has been tested for double this pressure. Stoneware pumps are used to circulate the brine.

## Asbestos Cement Appears in Pipe

AFTER proving itself in such severe conditions as quencher housing in coke plants, Transite, a compressed composite of asbestos fiber and portland cement, has now appeared as chemically resistant piping. For especially severe conditions, it is further impregnated with bitumen.

In its use as pipe, the material was first applied to water mains and flues. In spite of its absorption of water, it remains impermeable and gives a higher delivery capacity, due to the smoothness of the walls, than steel. This smooth interior, of course, is not impaired by corrosion.

In general, Transite pipe can be laid in the soil without any further covering. It has a low heat conductivity and at the same time a high temperature resistance conveying liquids and gases up to 700 deg. F. In textile mills, dye plants, bleaching plants and the like, it is being used to carry solutions or water which must be free of rust. Certain strong acids affect it and its choice becomes a matter of comparable tests with other commercially available materials.



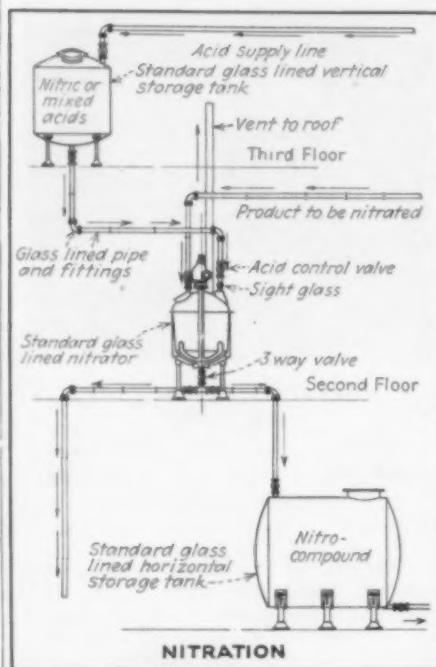
ASBESTOS PIPES DON'T RUST

## Complete Process Hook-Ups an Aid Against Corrosion

### Troublesome Chemical Reactions Yield to Glass-lined Equipment, Use of Which Is Increasing

CHLORINATION, nitration and sulphonation are bad actors among the chemical reactions. Although widely used in process industries, the chemical engineer has not always succeeded in standardizing them to the same extent as such physical operations as distillation, evaporation, filtration, or crushing and grinding. As a result of this lack of standardization, units of equipment are often assembled which, because of different materials of construction, introduce corrosion problems that result in contamination of products, decreased yields and excessive cost of maintenance. Furthermore, wet chlorine and hydrochloric acid, and nitric and sulphuric acids of varying strengths are among the most corrosive chemicals in common industrial use. Fortunately, however, glass is one material that uniformly resists all of these corrosives.

Therefore, it is a significant trend to find increasing use in chemical industry of complete hook-ups of corrosion resistant equipment for carrying through the entire processes of chlorination, nitration and sulphonation. The Pfaudler Co. of Rochester has developed its glass-lined equipment on a standardized basis with interchangeable units that make it possible to vary the hook-ups sufficiently to meet practically every condition likely to be encountered in these reactions. The accompanying flowsheets show in elementary form the type of hook-ups that are used for this service. It will be noted that



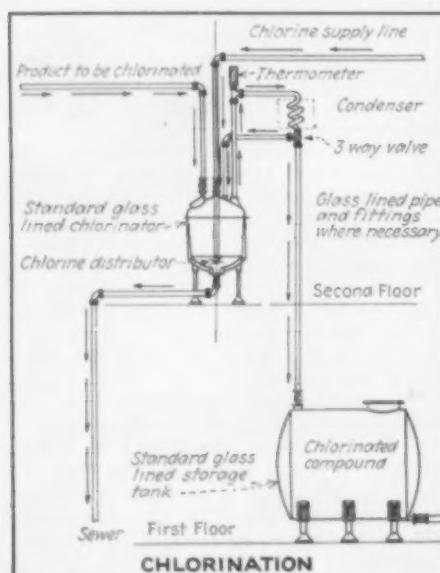
glass-lined pipe and fittings as well as storage tanks, reaction vessels and other process equipment may be used throughout the entire process, thus eliminating possible sources of contamination and corrosion.

In the preparation of fine chemicals, pharmaceutical products, and dye intermediates, these chemical reactions are usually conducted on a batch basis. Therefore, when changing from one process to another, thorough cleaning is necessary to prevent contamination. One of the great advantages of the glass-lined assembly is that the smooth, non-absorptive surface requires a minimum of labor for cleaning.

### Carbon Increasingly Used In Chemical Equipment

BECAUSE carbon is unaffected by practically all acids, alkalis, and solutions of salts at most concentrations and working temperatures, its initial debut into chemical plant equipment a few years ago has been followed by an extension of its usefulness. It is offered by the manufacturers in molded, extruded and machined forms, which withstand mechanical and thermal shocks. It has become available in the form of brick and tile for digester and tank lining as well as other special shapes such as tubes, plates, beams, and pipe for structural work. A complete line of carbon Raschig rings for tower packings has also been developed by the National Carbon Co., Inc., Cleveland, Ohio.

In the paper plant it is used for lining digesters and in electrochemistry to resist chlorine and fused aluminum salts. Its use in electrical precipitators for phosphoric and sulphuric acid plants was described by A. D. Camp in *Chem. & Met.* (Vol. 37, p. 676, 1930).



## Ply-Metals Appear As Economy Strikes Stainless Alloys

### Acid-Resisting Qualities of New Product Promise Great Savings in Many Process Applications

RUMORS that another commercial two-ply, stainless steel is being developed, have been substantiated by a recent announcement of the Ingersoll Steel & Disk Co., Chicago (division of the Borg-Warner Corp.), which is now offering Ingoclad produced from a composite ingot. The success of the process depended on developing a perfect bond between a stainless steel and carbon steel backing.

It is now being produced at the New Castle, Ind., plant of the company, in various sizes, but work is still being done to complete the line of commercial forms. It can be deep-drawn, stamped, welded, formed and polished. Because it has the same acid-resisting properties as the solid alloy steels, it promises economical use in tanks, retorts, pressure vessels and other process equipment.

Ply Krome, made by the Industrial Welded Alloys, Inc., is a bond of mild steel and corrosion resisting alloys, welded together in a slab or billet. This can be rolled out to any desired thickness or ratio of sheet, heavy pressure vessels running as high as a ratio of 1 to 30. In some cases, the veneer is applied on both sides. Tests have indicated that the composite metal can be bent, drawn, spun or flanged, by the usual practice, without affecting the bond.

Chrome-Clad, again, applies a resistant surface by coating a mold with powdered ferro-chromium and pouring into it a plain carbon or low alloy steel. The result is a thin cased surface of chrome-bearing metal, somewhat more resistant to high temperature, oxidation, and corrosion than ordinary carbon steel.

### Structural Board Sheathed With Metal

VARIOUS standard types of structural board are now bonded with thin sheet metal called Ferroclad, made by the Truscon Steel Company, Youngstown, Ohio. Stainless steel, galvanized iron, aluminum, Monel, copper and other desirable types of metal sheathing are cemented under pressure to the non-metallic board, and the edges, in so far as they may be exposed, can be sealed by a special compound or by metal strips.

Depending on the type of service to be encountered, the core can consist of plywood, insulating board, pressed wood board, or heat-resisting compounds. The panels are fabricated to a maximum of 4x12 ft. in area and up to 3 in. thick. The thinnest core used is  $\frac{1}{8}$  in.

## Gasoline Stowage Calls for Special Alloy Fabrication

### Problem of Permanent Resistant Fuel Cells for United States Airplane Carrier Is Solved

GASOLINE stowage tanks for U. S. airplane carriers have an unusual service. The fuel is removed by forcing salt water into the tanks, thereby keeping them constantly filled with gasoline, salt water, or a layer of each. The tanks are kept filled in order to prevent collection of flammable vapors in an air space. The location of the tanks in the hold of the ship makes replacement practically impossible after the ship is in service. Therefore they must be constructed permanently and corrosion resistant to gasoline and salt water.

The requirements were filled by the Blaw-Knox Company, Pittsburgh, with an electrically welded 18-8 steel, according to the choice of the U. S. Navy. Riveting and oxy-acetylene both had drawbacks, because of possible carbon formation, porosity, or temperature effects. By the use of electric welding, with properly coated electrodes, the action is so rapid that carbon precipitation and other contamination is extremely slight.

The 27 gasoline stowage tanks built for the airplane carriers varied in dimensions and shape. Their length was from 19 to 26 ft., their inside diameter  $5\frac{1}{2}$  to 10 ft.; some of them were tapered. Because of their large size, annealing was difficult and required very accurate bracing. After all welding was completed, they were brought up to 1,800 deg. F. and then withdrawn to the open air, where cooling was hastened by blasts of air. After hydrostatic and air tests, they were then sand-blasted and passivated. In spite of the high coefficient of expansion of the alloy, and the comparatively thin shell, ( $\frac{1}{4}$  to  $\frac{1}{8}$  in.) the tanks were in very good alignment after the process.

### Reinforced Brickwork Is Returning to Favor

REINFORCED brickwork, although first used in England more than a century ago, may truly be characterized as a new construction material, for it is only within the past few years that any concerted effort has been made to utilize it in this country.

In this system of construction the horizontal and vertical steel reinforcement is placed in the mortar joints in practically the same amount and arrangement as for similar construction in reinforced concrete. Design is still more empirical than scientific. However, new test data are rapidly being accumulated, and several scientific studies are being planned, so that the next

few years should witness considerable progress toward a rational design procedure.

Recent examples of reinforced brick-work in this country include cylindrical storage bins, piers, a tank inclosure, a small bridge, and a variety of columns, floor slabs, lintels and building walls.

### Compounding Sulphur Reduces Its Brittleness

SULPHUR is brittle and cracks easily, but its resistance to chemical reagents is widely appreciated. When compounded with minerals and cellulosic materials, however, the advantageous properties of the sulphur come to practical fulfillment. Fiberboard, impregnated with 30 to 40 per cent of sulphur has been widely adapted in industrial packing and shipment because of its firm rigidity and imperviousness. Compounded with minerals, it is formed into ceramic-like ware which is not only impervious but impact-resistant. A modified form of this has been used as packing material in water mains, where it combines ease of application and flexibility. A carload of sulphur is being used every month for packing ball and socket joints in pipe lines.

Certain mechanical parts are made of a sulphur-mineral compound to resist etching sprays. Sulphur, in combination with wood pulp, containing 80 per cent by weight of the former, is the basis of a new casting plastic. It is hard, can be pigmented, and because sulphur only costs 1 cent a pound is cheaply producible.

### Lead Sets Record in Sulphuric Acid Plant

WHEN the Grasselli Chemical Company last year dismantled its chamber sulphuric acid plant at Beaver Falls, Pa., it had an excellent opportunity to examine the lead lining after 32 to 47 years' exposure, the original plant having been built in 1884. In the chambers a 6 lb. chemical lead was used for curtain and top, 8 lb. lead for the bottom, and 10 lb. for the pan. Patching had been necessary on about 15 per cent of the area throughout the plant's life.

The lead, on dismantling, appeared to be in excellent condition; its loss in thickness was calculated from representative sections and found to give the following comparisons:

Chamber	Built	Original Weight	Present Weight
1	1899	6 lb.	$5\frac{1}{2}$ lb.
2	1899	6	$5\frac{1}{2}$
3	1884	6	$5\frac{1}{2}$
4	1884	6	$5\frac{1}{2}$
5	1884	6	$5\frac{1}{2}$

The plant was originally constructed to burn iron pyrites, but in 1919 brimstone was substituted and used for the rest of the time.

## Anode Coatings A Protection to Moving Equipment

### Abrasion and Corrosion Radically Reduced by Their Use, Reports the Goodrich Rubber Company

ABRASION in process equipment has, in many instances, been radically reduced by the use of "anode" coatings, H. E. Fritz of the B. F. Goodrich Rubber Co. reports. In a wet vibrating-screen operation, parallel apparatus of spring steel and rubber surfacing was used. The former had a life of 212 hr. and the rubber-covered screen



RUBBER CUTS ABRASION

Anode-rubber covering of this pump impeller increased its life indefinitely in service where uncovered impellers lasted only a month.

lasted 2,847 hours,—handling 84,424 tons in all.

The impeller of a dust pump was operated at a speed of 3,400 r.p.m. for 16 hr. a day. It was covered with anode rubber and measured 24 in. across. In similar service uncovered impellers have lasted about a month, but this particular job required three months and in the end the impeller was still in service. In all, it exhausted about 86 tons of rock dust.

### Bronze Made to Resist Fatigue and Corrosion

DEVELOPED especially to withstand the corrosive effect of sea water and salt solutions, the new P-M-G metal of the Phelps Dodge Copper Products Corp., is a modified tin bronze embodying superior physical properties as well. It has become available in cast and wrought forms. Six per cent lighter than other tin bronzes, it works successfully in applications demanding temperatures of 1,000 deg. F. It is being used in such different parts as valves, pump impellers, spindles, and gears, especially where salt solutions are present.

## Selenium Produces Fabricating Ease In Alloy Steels

**Sister of Sulphur Proves More Attractive Companion to the Chrome-Nickel Steels**

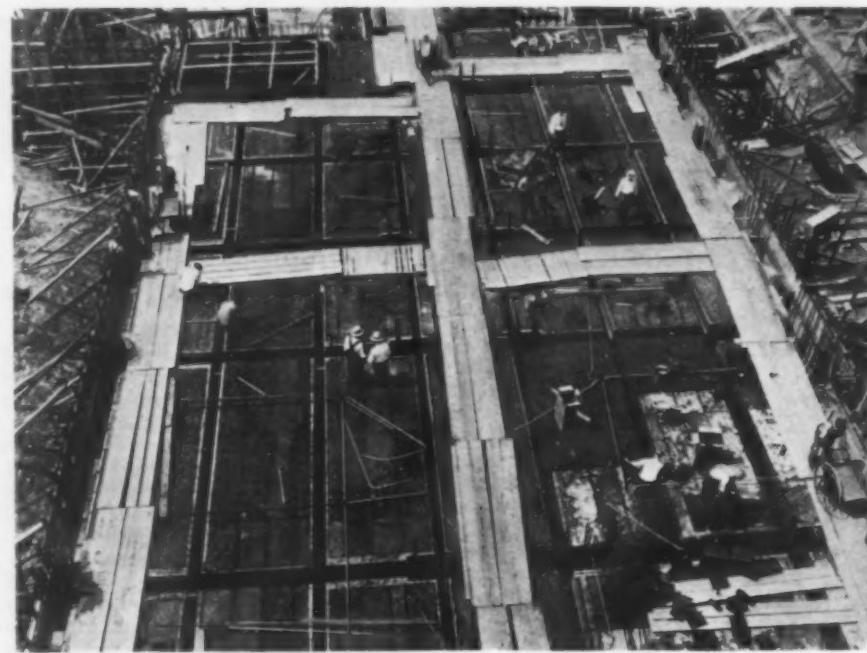
RIVALRY has arisen in the sulphur family since selenium has been successfully incorporated in 18-8 steels by the Carpenter Steel Company, Reading, Pa. In the recent past, sulphur has been the principal additive to ease the difficult working qualities of chrome-nickel steels, but there are various difficulties that accompanied its use which have favored the recent debut of selenium in ferrous metallurgy.

A byproduct of copper smelting and sulphuric acid manufacture, selenium has found its principal use in the past, in the light-sensitive cell, as glass colorant, and as rubber compounding ingredient. After Carpenter's experimental work had been completed, they found that in practice ferro-selenium had to be added to the molten steel. Shortly before the pour, a specified quantity is added on the surface of the metal and quickly compounds with the steel. The casting, hammering, rolling and annealing proceed just as in any other chrome-nickel alloy and its final composition is 18 per cent chromium, 9 per cent nickel and 0.25 per cent selenium. Its advantage is that it can be drilled, tapped, threaded and otherwise machined with ordinary shop tools and practice.

Selenium is said to have several distinct advantages over sulphur as a free-cutting agent. The latter, when added to a steel bath, combined to form sulphides which are entirely insoluble in steel and occur in the castings as small non-metallic particles. In the hot working of the steel, these are drawn out into long threads which interrupt the continuity of the metal and render it less ductile in a transverse direction.

Selenium also forms metallic selenides, but as these are partially soluble, there is less stringer formation and the finished product is much tougher and less subject to transverse fracture. Experiment indicates that the free-machining qualities are proportional to the total selenium content. Tensile and impact tests made transverse to the direction of rolling on free-machining alloy steel show that selenium yields about one-third greater elongation and reduction of area and twice the impact resistance of sulphur. The ultimate strength is the same for both types.

Far from impairing the corrosion resistance of this alloy, selenium increases the passivity to specific reagents such as boiling solutions of acetic acid and aluminum sulphate and certain other corrosives met in chemical industry.



CORK HOUSES ARE COMING

A 4-in. thickness of corkboard insulates the walls and ceilings of this group of temperature-controlled laboratory rooms in the new Physics and Chemistry Laboratories at M.I.T.

## Breakproof Glass Here, Say Reports From Abroad

ACCORDING to the Berlin correspondent of *Chem. & Met.*, a new strong, non-reinforced glass called "Sekurit," made by the Glaswerken Bicheroux & Co., has appeared on the market. It is said to look just like ordinary glass and does not change with age. With its strength is combined a high elasticity, and when fractured by a sufficiently strong blow, the material does not shatter into splinters but crumbles up into granular pieces without sharp edges.

## Magnesium Alloys Have Much Structural Strength

WHILE in Europe such light magnesium alloys as Elektron have long found favor in various industrial designs there are now available in this country six standard alloys under the group name Dowmetal, made by the Dow Chemical Co., Midland, Mich. They are not specifically designed for resistance to chemicals, their great advantage being a superiority over all other cast metals in tensile strength on an equal weight basis.

The alloy with maximum corrosion resistance is, curiously enough, the one with 98.5 per cent of magnesium and only 1.5 of manganese. It is intended, however, for cast and fabricated parts not subject to maximum stresses. The strongest alloys

contain only 90 to 92 per cent of magnesium, up to 10 per cent of aluminum and small percentages of manganese, cadmium, and copper. In between the two extremes are the ductile varieties with good strength, working properties, and without the necessity for heat treatment.

These metals are available as castings, forgings, sheets and plates, bars, rods, and structural forms.

## Tank Car Leads Way To Nickel-Clad Steel

SINCE the General American Tank Car Co. had the first Nickel-Clad steel tank cars built for the transportation of caustics, the Lukens Steel Co. has applied the principle to a large range of process equipment. The material is a hot-rolled ply-metal produced from pure nickel and flange-quality steel. The product provides all the corrosion resistance and other advantages of pure nickel, in combination with the structural strength of steel at a cost which makes it economical for heavy equipment.

The relative thickness of the nickel can vary between 10 and 20 per cent according to the use. Fortunately, the thermal coefficients of expansion of nickel and steel are practically the same. Besides its application in the transportation of caustic soda, nickel-clad steel is being used in laundries, dyestuff manufacture, cellulose acetate mixers, vacuum evaporators, resin manufacture, soap boiling kettles, and peroxide bleaching kiers.

## Weld Decay and Creep-Studied in Corrosion Tests

### Device Constructed to Measure Special Causes of Breakdown of Materials Used in Equipment

CREEP, weld decay, and erosion in metals are being subjected to a series of special studies by the Westinghouse Research Laboratories, East Pittsburgh, Pa. They are all factors which are not directly dependent on the resistance of a given metal surface to different chemical reagents. Following the proper choice of material, however, they stand next in importance in the choice of enduring equipment.

For the study of welds, an accelerated corrosion device has been constructed which subjects specimens to intermittent immersion in a corroding liquid. Suddenly the samples become submerged for a definite period, leaving them at rest; then they are removed and exposed to the air for a definite period. They are in motion only for a very small fraction of the cycle. The apparatus, whose timing can be regulated, is equipped to keep the reagents at constant temperature. The samples are suspended from the rack by glass hooks, horsehair, or silk.

### Creep Tests Especially Difficult

Accelerated creep tests have not been as satisfactory, but they have at least emphasized the numerous precautions and possible errors in dealing with the subject. Since creep requirements are often restricted to as small a value as 0.001 per cent per year, even with very accurate measurements the length of a creep test gives no indications of the long conditions of service. Extrapolation of curves becomes necessary and large errors can easily result. Furthermore creep is affected by the previous history of the material, and the tests may unconsciously be recording a condition that is only temporarily stable. And if the engineer is satisfied only with meeting the test specification, it naturally loses much of its significance in service. In short, the available information indicates that the experimental creep rate alone is not a satisfactory basis for design.

To study alloys subjected to rapid erosion, small cut slugs intercept two minute jets of water as they whirl against them at 20,000 r.p.m. In comparable tests, different compositions of resistant iron and steels were cut in half in 2-4 minutes; Stellite, lasted 10 minutes; iron nitride held out 15-20 minutes. The slugs travel at 13½ miles a minute and thus receive 667 impacts per second.



**GETTING CORROSION DATA**  
Westinghouse tests by dipping and removing samples periodically.

### Nitrated Cloths Now Produced Here for Filter Service

ALTHOUGH cloth of nitrated cotton has for many years been produced abroad for the filtration of acid solution, recently a domestic cloth has become available in "Doracid," made by the Dorr Company, New York. While its tensile strength is only 70 to 80 per cent of that of untreated cotton cloth, it has a harder surface from which a filter cake is more easily detached. In resistance to the action of sulphuric, nitric and hydrochloric acids, it has been shown to be far superior to any other textile material. In a press used solely for filtering 30 per cent sulphuric acid solution, at normal temperature, a Doracid cloth lasts over 100 days, representing 70 filtrations. But while the material is recommended for strength up to 40, and temperatures as high as 90 deg. C., it has been successfully used for filtering even 60 per cent sulphuric acid at 100 deg. C. Chemicals not recommended for contact with Doracid are those which attack nitrocellulose. Among them are alkalis, sulphides, alcohol and other solvents, as well as such reducing agents as ferrous sulphate.

## Remedies Found For Intergranular Corrosion of Steel

### Two Distinct Methods Employed to Reduce or Eliminate it in Metal That Is Used Commercially

ONE of the few shortcomings of the austenitic stainless steels of the 18-8 type caused considerable annoyance in the products of early manufacture. A very characteristic form of susceptibility to intergranular corrosion was developed in these austenitic materials during or after an exposure to a temperature within the general range of 1,000 to 1,500 deg. F. The susceptibility of the grain boundary material to this type of attack is believed to be induced somewhat as follows:

Within the temperature range indicated, chromium-carbide or chromium-rich carbide precipitates at the grain boundaries of the metal; the carbide particles probably contain as much as 90 per cent chromium. Their formation locally depletes the immediately adjacent metal of its chromium, so that it is too lean in this important element along the grain boundaries to resist attack. With prolonged heating chromium may diffuse from the reservoirs within the grains and restore corrosion resistance to the grain boundary regions.

### Chromium Reaction Forestalled

The severity of the effect is about proportional to the carbon content. For this reason metal with about 0.06 or 0.07 per cent carbon is comparatively free from this behavior, except perhaps after extremely long exposure. Reduction of the carbon content to about 0.02 or 0.03 per cent carbon would eliminate the effect altogether, but this is of course impractical at the present time.

However, two distinct methods may be employed greatly to reduce or eliminate intergranular susceptibility in commercial metal. It will be quite clear that the addition of an element, which will permanently combine with the carbon as a relatively

### How Stoneware Has Improved Since 1921

Percy C. Kingsbury of the General Ceramics Co., in a paper before the Canadian Chemical Convention, cited the following figures to indicate improvements in stoneware:

Physical Properties	Optimum Values	
	1921	1931
Ultimate Strength Tension.....lb. per sq.in.	1,650	7,500
Ultimate Strength Compression.....lb. per sq.in.	82,800	116,500
Ultimate Strength Bending.....lb. per sq.in.	5,900	113,950
Ultimate Strength Torsion.....lb. per sq.in.	3,570	114,580
Modulus of Elasticity.....lb. per sq.in.	$5.95 \times 10^6$	$5.95 \times 10^6$
Coefficient of Thermal Expansion per deg. F.....thick per hour per deg. F.....	$2.3 \times 10^{-6}$	$0.083 \times 10^{-6}$
	0.9	2.64

insoluble carbide, will prevent the formation of chromium-carbide. Several of the active carbide-forming elements will suffice; titanium has been found by the Crucible Steel Co. to be one of the most successful of these elements. Tungsten and molybdenum function somewhat similarly in high concentration, such as 4 or 5 per cent, but they also tend to prevent the preservation of the pure austenitic state, a circumstance not always desirable, although they too constitute valuable addition agents. A titanium addition amounting to 5 or 6 times the carbon content appears to be quite effective when properly utilized.

#### Dispersing Chromium Carbide

Another method for greatly reducing intergranular susceptibility developed in the U. S. Steel Corporation permits the formation of some chromium-carbide but in a harmless distribution. By appropriate mechanical and thermal treatment carbide may be induced to precipitate substantially throughout the grains, as well as, or perhaps instead of, along the grain boundaries. Under these conditions the precipitation is so general that not much local depletion of chromium can result, and a comparatively short time in the vicinity of 1,400 deg. F. permits homogenization of chromium. This method provides for the elimination of susceptibility to intergranular corrosion without recourse to special alloying elements. The metal suffers a very slight loss in ductility by the treatment, but gains slightly in strength. In many applications wherein the higher strength is no disadvantage the method is quite satisfactory.

#### Three Resin Types of Varnish Now Available

THE FIRST real resin varnish was of the baking type. This kind of phenolic resin is being used, for example, to cover the metal screening of an air filter, where it holds the fine fibers in place; in cleaning, the screen is run through a bath of oil and leaves the resin intact. Tanks for evaporating benzol from sulphonated acids have been successfully coated with the baking type. Incidentally, it also serves as crack filler in glass linings.

The quick-drying type represents the development of an oil soluble version of phenolic resin. It resists sunlight, water, acid, mild alkali and alcohol and dries within a few hours. It is not as durable as the previous type, but is often used when that is impractical. To a great extent it is used to cover industrial equipment, pumps, pipe, and paper mill machinery, where unfavorable atmospheric conditions prevail.

Recently a new type has been described by the Beck, Koller & Co., Inc., whose Beckosol is not only soluble in a drying oil, but when heated with it, reacts and forms a complete resin without inactive ingredients. The reaction is not complete, so that the compound is still liquid and will dry on exposure. The material is so new it is not yet widely used.

#### "Haveg" Offers Special Properties For Chemical Use

#### Resinoid Combined With Asbestos for Plant Size Equipment—To Be Manufactured in U. S.

INTRODUCED by the Säureschutz G.m.b.H., Berlin, to chemical industry on the Continent several years ago, Haveg in the form of larger equipment has found its way into many Continental chemical operations. It is composed of synthetic resin and high silica asbestos. Different grades, with different constitutions are offered for various demands made on it.

Up to the present, vessels as large as 9 ft. in diameter and 10 ft. high, without any reinforcement, have been made. When there is erosive action, it is recommended to add a partial lining of glass or stone plates. In general the material is useful up to 130 deg. C. although its special quality is said to withstand 200 deg. C. At 300 deg. it begins to char. In appearance Haveg is black or dark brown; it is made in special odorless forms for the pharmaceutical and food industries and in another form for use with fluorine compounds.

Its resistance to various chemical agents is very different, because of its unusual components. But particularly valuable is its resistance to phosphoric acid and hot and cold hydrochloric acid, of all concentrations. Tests conducted at 100 deg. C. showed a loss in weight of 1.15 per cent in 30 days in 15 per cent HCl, but the last occurred in the first few days, due to a normal hardening phenomena in the resin. It also resists molten sulphur and most organic solvents. It is not recommended for strong sulphuric acid or nitric acid of any concentration. Phenol, aniline, strong formic, chromic and acetic acids also attack it to some degree.

Haveg will be manufactured in this country, under the German patents, by the Haveg Corporation, with headquarters at Newark, Delaware. Identified with the corporation are J. P. Wright and L. W. Tarr of the Continental-Diamond Fibre Company, manufacturers of vulcanized fiber and laminated phenolic products. Plant facilities are already provided for and it is expected that production will be well underway by the first of the year.

#### When Beer Comes Back

IF MODERN BREWING practice in Germany, Switzerland and England foreshadows developments likely to occur here some day, American stainless steel will find another sizeable market in yeast wagons, fermentation vessels, mashtun covers, pipe lines, valves, buckets and shovels. Electro Metallurgical Co. points out that even the old familiar beer keg is giving way abroad to shiny drums of 18-8 chrome nickel steel.

#### Alkyd Resins as Coatings Proved of High Tenacity

ALKYD resins, of the typical constitution glycerol-phthalate, have in the past years become available in all sorts of modifications. The saturated types are used mostly in nitrocellulose lacquers; unsaturated types, modified with fatty acids, are usually applied by themselves in combination with drying oils and other resins. In most cases they are used where their tenacity to metals appears to best advantage, but more recently they have also been used for outside coatings.

The first group mentioned is especially useful for preventing penetration of ultraviolet rays, for retention of surface, and preservation through their toughness. In the second group, water resistance must be achieved by various additives, such as phenol compounds. They dry in the air and display the general properties of the group otherwise.

That these compounds are going to become industrial factors not only as coatings for metal, but also as highly versatile solid forms, is evident from the descriptive article in *Chem. & Met.*, August, 1932, in which J. G. E. Wright describes the most recent work of the General Electric Company in this field.

#### Modifications Fit Phenolic Plastics To New Service

#### Fiber Lengths of Filler Show Exceptionally Increased Flexibility and Functional Resistance

PRODUCERS of synthetic resins have become increasingly aware that their durable products can profitably be developed for industry. As a result, in the last three years the phenolic plastics have been studied in two basic directions: for coatings and for improved mechanical services in industry. Within the scope of the latter, fiber lengths of filler have been increased to give higher shock and frictional resistance. Exceptional flexibility after hardening has been achieved because of the marked temperature changes occurring in any metals that may be bonded with them. For use in meters, pumps, valves, pipe lines, and so on, the water resistance has been improved; and improved heat resistance now allows safe use of some objects up to 450 deg. F.

#### Application in Chemical Plants

Among the newer plastic applications appearing in the plants, are pipe and fittings used to convey dilute acids and other corrosive liquids. Some objects constructed of it required resistance to hot water on one side only, and in a case like this, the

## MODERN MATERIALS

material stood the action of boiling water on one side for a year without showing any warpage. In the textile industry, which laminated resins early invaded, they are employed in spinning tops, bobbins, and various mechanical parts. Some of the latter that appear in other industries

are gears, doctor blades, rollers, and bearings.

An unusual structural use is in laminated sheets up to 8 ft. long, which are bonded to various thicknesses of Celotex or Transite. The resin is only  $\frac{1}{16}$  in. thick, but gives a smooth protective surface that

is especially desirable wherever construction demands resistance and easy cleaning.

As a bonding agent, the resin is being used to attach plastic and rubber or metal and for sealing pores of metal castings. It is being bonded with refractory materials to give abrasive cutting wheels.

# Plastic Products and Producers

Name	Description	Manufacturer or Reference
Abalak*	PF, s.	Kunststofffabrik Dr. Fritz Pollak, Vienna
Abalyn	D.	Hercules Powder Co., Wilmington, Del.
Acelite	Bituminous	American Hard Rubber Co., Akron, Ohio
Acelloid	CA, m, F.	General Plastics Corp., London, SE 13
Acétophane	CA, P.	Soc. Industrielle de l'Acétophane, Brussels
Acetylon	CA	Dynamit A. G. vorm. Nobel, Hamburg
Acidur	Acid-resistant moldings	Cable Mfg. Co., Ltd. England
Aerialite	X.	S. Alcock & Co., Ltd. England
Agalyn	Px, dentures	J. D. Whyte, Pittsburgh
Akalin*	C.	Akalin Kunsthornwerke A. G., Vienna
A-K	PF m. asbestos	CGP 29 15954 (1932)
Albert*	PF ? t.	Chem. Fab. Dr. Kurt Albert, Wiesbaden, Germany
Alborid	Px	Kausch
Acolite	Px, dentures	Ransom & Randolph Co., Toledo, O.
Aligine	Algin plastic	Paul Glaser
Alkalit*	C.	Alkalit Kunsthornwerke A.G., Vienna
Amalith	PF	Kausch
Amberdeen	PF	Kausch
Amberglow	Pft, luminous	Laboratoires Industriels d'Assières, Paris
Amberit	PF	Kausch
Amberol*	D.	Resinous Products Co., Philadelphia
Ambroin*	PF and other	Ver. Isolatorenwerke A.G., Vienna
Amerloid	C. f.	American Plastics Corp., New York
Amiantine*	Copal plastic	Soc. Roux, Paris
Aiproid	Px	Kausch
Argonite	Px	Kausch
Arki	Wallboard	Isoleringfab. Arki, Stockholm, Sweden
Aroclors	Chlorinated diphenyl resins	Swann Chemical Co., Anniston, Ala.
Asbestite	B. asbestos	A. Vaucheret, Paris
Akrol	PF	Anglo-Scottish Chem. Co., General Plastics Corp., London, SE 13
Astrinite	Bituminous	H. Clarke & Co., Manchester
Atlas	PFI	Willmott, Sons & Phillips, Ltd., England
Avecolite	PFI	CGP 29 15956 (1932)
Axolithe	C.	Synthetic Plastics Co. Inc., New York
Beetle 212	UFm	Nobel Chemical Finishes, Ltd., Slough, England
Belco	?	Kalle & Co., A. G., Wiesbaden-Biebrich, Germany
Bellaphan	Px, etc.	Barret & Elers, Ltd., London E3
Belleroid	Rubber base	Belplastic, Ltd., London, W 10
Belplastic	F	British Xylonite Co., Ltd., London, E 4
Bex	PF, etc., F.	British Xylonite Co., Ltd., London, E 4
Benzoid*	CA	British Xylonite Co., Ltd., London, E 4
Bicella	V. cellophane-coated netting	Kalle & Co., Wiesbaden-Biebrich, Germany
Bikakapeln	V, bottle caps.	Kalle & Co., Wiesbaden-Biebrich, Germany
Bilac	F	W. E. Amies & Co., Ltd., Sheffield
Bogophane	V. P.	Soc. anon. Bogophane, Palermo
Bois Cramé Gelatine		Kausch
Bois Durci	Albumen	Cie. Gén. d'Electricité, Paris
Britmac	PF, C, F.	C. H. Parsons, Ltd., Birmingham, England

## Revised Table Supplements Aug. 1931 List

The plastics identified below are additions to or modifications (marked by\*) of the list prepared by A. F. Randolph of the du Pont Viscosoloid Company, Arlington, N. J., for *Chem. & Met.*, Vol. 38, No. 8, Aug. 1931. The code and abbreviations used are:

B	Inorganic	Px	Pyroxylin
C	Casein	SG	Safety glass
CA	Cellulose Acetate	UF	Urea-formaldehyde
D	Resin used as ingredient	V	Viscose
F	Fabricator's trade name	W	Wood Fiber
P	Packaging material	X	Miscellaneous
PF	Phenol-formaldehyde	?	Nature not known
		GP	Glycerol phthalic anhydride
f	Forms: sheets, rods, etc.	m	molding compound
l	Laminated board, etc.	s	Soluble for varnish, impregnation, etc.
t	Turnery type (not moldable); articles made by casting and machining		

CGP — *Le Caoutchouc et la Gutta-Percha*, 49, rue des Vinaigriers, Paris

Kausch — "Handbuch der künstlichen plastischen Massen," by O. Kausch, J. F. Lehmann, Munich, 1931

Kunststof — *Kunststoffe*, J. F. Lehmann, Munich

Rev. Mat. Plast. — *Revue générale des matières plastiques*, 29, rue Turgot, Paris

Transparentfolien — by M. Halama, Bodenbender, Berlin, 1932.

Name	Description	Manufacturer or Reference	Name	Description	Manufacturer or Reference
Bronokapselin	V, bottle caps.	Chem. Fab. Heyden, A.G., Dresden-Radebeu	C-E 950	PF, dentures	Coe Laboratories, Inc., Chicago
Camphoid	Px	Kausch	Cinerit	X	Pétrier, Timot & Raybaud, Switzerland
Capsules de Glutold	Gelatine	Kausch	Ciro	Px, records	Celluloid Printers, Ltd., England
Carnalithe	C.	Barthélémy	Clarifoil	CA, P.	British Celanese, Ltd., London
Carnold*	Discontinued		Claritone	F.	Ashley Wireless Telephone Co., London
Casine Lurville*	Discontinued		Clarophan	P, gelatine	Continental Gelatine Ind., Michelstadt, Germany
Catalin*	PF t, s.	Am. Catalin Corp., New York	Clémateite	PF	Rev. Gen. Nat. Plast 8 157 (1932)
Cedra-Glas	Coated netting	Haver & Becker, Oelde, Germany	Clematite	Bituminous	Kausch
Cégéite*	Synth. resin plastic	Cie. Générale d'Électricité, Paris	Cornalithe	C.	de Charraud, Rueil, France
Celastic*	Px, boxtoe material	Celastic Corporation, Arlington, N. J.	Cornit	Horn plastic	Kausch
Celanite	Laminated board	Micanite & Insulators Co., London E 17	Coronal	UF	Soc. l'Ambrolithe, Paris
Celliglass	V, P	Chem. Fabrik Celliglass, Limburg, Holland	Crepophane	P	Linium Products Syndicate, Ltd., Nottingham, England
Celinfoil	P	Celinfoil, Ltd., Manchester	Crystalite*	UF	Robm & Haas, Philadelphia
Celloforme	?	Soc. la Celloforme, Paris	Cumar	Cumarone base plastic	Barrett Co., New York
Cel-O-Glass	CA-coated netting	Acetol Products, Inc., New York	Cupren	Copper-acetylene	Kausch
Cello-Metall	Cellophane with metal foil	Kalle & Co., Wiesbaden-Biebrich, Germany	Daspi	F	Deutsch. Allgem. Spritzgusswerk, Nürnberg, Germany
Celomoid	CA, injection m.	F. A. Hughes, Ltd., London	Deedoid	F	Aberdeen Comb Works, Aberdeen
Cellophane*	V, P	Add: Canadian Industries, Ltd., Montreal	Dioferit	Px	Kausch
Cellosilber	Celluloid with metallic coating	R. Kiefer, Dresden	Dorex*	PF	Dorex, Paris
Celluline	Px	Kausch	Dulux	D	E. I. du Pont de Nemours & Co., Philadelphia
Cellulodine	Px	Kausch	Duo-lite*	SG	Duplicate Corporation, Pittsburgh, Pa.
Cellulosine	Px	Cadoret & Degraide	Dura C	PF, s.	Chem. Markets 30, 40, (1932)
Cellusine	P	Langheck & Co., London, EC 3	Durophene	PF, s, m	Scott, Bader & Co., London, WC 2
Cetaphane	V, P	Transparent Paper, Ltd., Bury, England	Durolit	?	Heko-Werke, Berlin-Tempelhof
			Dux	D	Nobel Chemical Finishes, Ltd., Slough, England

## MODERN MATERIALS

Name	Description	Manufacturer or Reference	Name	Description	Manufacturer or Reference	Name	Description	Manufacturer or Reference			
Ebénit...	X	Etablissements Grivolas, Paris	K-gutta...	Insulator	Rev. Mat. Plast. 8, 188, (1932)	Piaphan...	P, gelatine foil	Langheck & Co., Esslingen, Germany			
ECA...	C, etc., F.	Bruggemann y Cia., Mexico	Kleko...	Gelatine bottle cap	Kleko Flaschenverschluss-Fab., Frankfurt	Piuvisin...	UF	Kunstharzfabrik Dr. Fritz Pollak, Vienna			
Fécaillie 97%...	PF, t.	Labs. Ind. d'Asnières, Paris	Kodapak...	CA, P.	Eastman Kodak Co., Rochester, N. Y.	Plyafix...	C	Jos. Nathan & Co., Ltd., England			
Elastica...	SG, resin	I. G. Farbenindustrie, Frankfurt	Kornomit...	X	Kornomit A. G., Skagen, Denmark	Pollipas-Platten...	UF, I.	Venditor, G.m.b.H., Berlin			
Elephantide...	Laminated board	Mica & Insulating Supplies Co., England	Lactophane...	C, P.	Poyer Adv. Agency, London	Polysti...	F, Px, etc.	I. G. Farbenindustrie, Frankfurt			
Elefantbein masche...	Papier maché	Kausch	Laetélite...	C	Rev. Mat. Plast. 8, 87, (1932)	Priscal...	UF, t.	Soc. anon. des Matières Plastiques, Paris			
Elefantite...	Resin adhesive	C. Werfel	Lapisite...	B	Lapisite Marble Prod. Co., Portslade, England	Priama...	F	Mica Mfg. Co., Ltd.			
Epok...	Molding powders	English Plastics, Ltd., London	Lignostone...	W	Kausch	Crystal*	UF, t.	Add: Sicaloid, Ltd., London			
Krinold*	C	American Plastics Corp., New York	Linsden...	F	Brit. Thomson-Houston Co., London WC 2	Pyraheel...	Px heel covering	du Pont Viscocid Co., Arlington, N. J.			
Erinol...	Resin intermediate	Erinold, Ltd., London EC 3	Lissen...	F	Lissen, Ltd., Isleworth, England	Pyralin*	Px	Add: Canadian Industries, Ltd., Montreal			
Ernolith*	Yeast-aldehyde	Bücher & Krause, Leipzig	Lucent Reel	Px, film scrap	Rex Campbell & Co., England	Rayolith...	F	French Ivory Products Ltd., England			
Eosalite...	B	Marsahn & Fritsch	Lucenit...	PF, t.	Lucien Eltertzen Soc. Lyonnaise de Celluloid, Lyon, France	Reflite...	m	Dante Badino			
Zelliglass...	V, P	Langheek & Co., Esslingen, Germany	Lugdomite...	CA	Luxite, Inc., Boston	Resoglas...	Styrol	Advance Solvents & Chem. Corp., New York, N. Y.			
Esténite...	B	Kausch	Luxan...	UF, s.	Luxite, Inc., Boston	Rexalith...	C	Soc. la Rexalith, Paris XVIII			
Eswelit...	Asbestos-filled	Siemens-Schuckert Werke, Berlin-Siemensstadt	Luxite...	UF, m.	Rev. Mat. Plast. 8, 157, (1932)	Rezelite...	PF	Cussons Sons & Co., Manchester, England			
Eubooth...	T	Soe. anon. Eubooth, Paris XV	Marbell...	F	Ebonestos Insulators, Ltd., London	Rhodialine*	CA, P.	Soc. des Usines Chim. Rhône-Poulenc, Paris			
Fantaft...	UF	Rhein-Westfäl. Sprengstoff A. G., Troisdorf, Germany	Margolit...	Cold molded	Ver. Isolatorenwerke A.G.	Rhodidol*	CA, f, m.	May and Baker Ltd., London, SW 11			
Fiber Diamond...	T	Dermatine, Ltd., London	Mastolite...	PFI	Symetis Products, Ltd., Eccles, England	Rhodophane	CA, P.	Rev. Mat. Plast. 8, 319, (1932)			
Fibestos...	CA	Fiberloid Corp., Indian Orchard, Mass.	Meigold...	Sugar-aniline	Meigold Corp., Jersey City, N. J.	Schellit*	PF, t.	Add: Etablissements Kuhlmann, Paris			
Flaks-Kapseln...	CA, bottle caps	Kalle & Co., A. G., Wiesbaden-Biebrich, Germany	Mergalithe...	C	de Charraud, Rueil, France	Setabonite...	Resin-rubber	Mfr. d'Isolants et Objets Moulin, France			
Formapez Mocarta		Mica & Insulating Supplies Co., England	Metakaline...	PF	Rev. Mat. Plast. 8, 157, (1932)	Setacéglite...	PF, m	Add: Sicaloid, Ltd., London			
Formica*	PFI	Formica Insulation Co., Cincinnati, Ohio	Micas...	Lam. mica	Soc. Française le Micales Westinghouse El. & Mfg. Co., East Pittsburgh	Sicalite*	C	Sylvania Industrial Corp., Fredericksburg, Va.			
Galalith*	C	Add: Galalith, Ltd., London	Moldarta...	PF, UF, m	Moskalin...	C	Soc. Ind. de la Cellulose, Ghent				
Galliperte...	C	Cie Gén. d'Electricité, Paris	Mycalix...	Mica-glass	General Electric Co., Schenectady, N. Y.	Silaviplana...	P, gelatine	Folien-u. Flitterfabrik Hanau, Germany			
Gesphthal...	GP	Allgem. Elektr. Ges., Germany	Naily...	F	Nally, Ltd., England	Similex*	PF, t.	Labs. Ind. d'Asnières Paris			
Glutoid...	Gelatine caps	Transparentfolien 283	Nale...	V, sausage casing	Kalle & Co., Wiesbaden-Biebrich, Germany	Similit...	Pitch-asbestos, m, F	Solidite*	Solidite & Synthetic Mouldings, Ltd., London		
Gramaphold	For sound records	General Plastics Corp., London SE 13	Niloid...	PX	Ambri-Verwaltung, Berlin-Johannisthal	Syphrap...	CA ? P	Sylvania Ind. Corp., Fredericksburg, Va.			
Granitol...	Fabric decorated with celluloid	Deutsche Pliuvisin A.G., Germany	Nizinoid...	Gelatine plastic	Imperial Chem. Industries, Ltd., London SW1	Sylvania...	V P	W. T. Tant & Co., Ltd., England			
Gummite...	Bituminous	Mfr. d'Isolants et Objets Moules, France	Nobeline*	PF, t.	Ondoline...	D, m	Tego...	D, adhesives	Th. Goldachmid, A. G., Essen, Germany		
Hato...	P, gelatine	Follen-und Flitterfabrik Hanau, Germany	Nospilta...	f, transp. and translucent resins	Orolithe...	CA	Teiconax...	Bituminous	Telegraph Const. & Maint. Co., London		
Halimanite...	Albumen base	Kausch	Novite...	PF, m	Panilax...	Insulating mat'	Textol...	V, P, coated Al foil	Textol...	V, P, coated Al foil	Aluminium Walzwerke A. G., Singen, Germany
Halolum...	CA, F	British El. Installations Co., London	Nymphrap Extra...	CA ? P	Pantolit...	?	Textit...	F, acid-proof	Textit...	F, acid-proof	Cable Mfg. Co., England
Hellowell*	V, P	Feldmühle Papier- u. Zellstoffwerke, Stettin, Germany	Omeglite...	PF, m	Paragutta...	Rubber, wax, etc.	Thikol...	Olefine-polysulphide	Thikol Corp., Yardville, N. J.		
Heraklith...	B	Kunstst. 21 124 (1931)	Ondoine...	D, m	Paralac...	D	Transcetic...	P	Transcetic...	P	Plastics 7, 619, (1931)
Hormmaché...	Laminated paper	Kausch	Orolithe...	CA	Paralithe...	t	Transflex...	P, gelatine	Follen-u. Flitterfabrik, Hanau, Germany		
Hurtigache Holzmasse...	Wood-water glass	Kausch	Panilax...	Insulating mat'	Parfait...	Px, dentures	Transparenta...	CA, P	Transparenta, G.m.b.H., Berlin		
Iberolithe...	PF	Soc. l'Orolithe, Rueil, France	Pantolit...	?	Permaloid...	Px, F	Transpan...	P, cuprammonium	Bemberg, A. G., Wupperthal, Germany		
Idytol...	PF	Rev. Mat. Plast. 8, 295, (1932)	Phenoid...	PF, I	Phenol...	PF, I	Triacet...	CA, P	Chem. Weekblad 29 167, (1932)		
Infusite...	B	Mfr. d'Isolants et Objets Moules, France	Philite*	F, UF, PF	Phenophene	From tannery waste	Troton-Platten...	PF ? L	Venditor, G.m.b.H., Berlin		
Isolanite...	B	Kausch	Plaskon...	UF, m	Plastophene	From tannery waste	Ultraphan...	CA P	Lonsa, Weil am Rhein, Germany		
Isoilt...	PF	Soc. Française, Lyon, France	Plastone...	CA	Westinghouse El. & Mfg. Co., East Pittsburgh	Urocristal...	UF, m (transp.)	Urocristal...	UF, m (transp.)	Résines et Vernis Artificiels, Lyon, France	
Ivoris...	F	French Ivory Products, Ltd.	Plastopal...	UF, s.	Toledo Synthetic Products, Inc., Toledo, Ohio	Viaconit...	M	Viaconit...	M	Ver. Isolatorenwerke A. G.	
Ivrit...	PFT	Etablissements Kuhlmann, Paris	Plastope...	UF, s.	Soe. Nobel Francaise, Paris	Viralite...	CA-coated netting	Viralite...	CA-coated netting	Darlington Fencing Co., Ltd., London EC 4	
Ivryne...	C	Etablissements Feuillant J. A. Crabtree & Co., Walsall, England	Piaphan...	P	Polypas...	UF, m	Visco...	V, P	Chem. Werke Visco, Aussig, Czechoslovakia		
Jacelite...	F	Chemie u. Technik JMS, Hamburg	Piaphan...	P	Polymer...	UF, m	Viscocelle...	V, P	Courtaulds, Ltd., London		
JMS...	T	Callender's Cable & Const. Co., London	Piaphan...	P	Polymer...	UF, m	Vitrex...	CA-coated netting	Transparentfolien 284 Dalle Frères et Lecomte, Bousbecque, France		
Kalanite...	Insulator	Kelacoma, Ltd., Welwyn Garden City, England	Piaphan...	P	Polymer...	UF, m	Vitrophan...	P, gelatine	Continental Gelatine Ind., Michelstadt, Germany		
Kelacoma*	UF, m, F	Rev. Mat. Plast. 8, 87, (1932)	Piaphan...	P	Polymer...	UF, m	Walo-Kapseln...	V, bottle caps	Wolf & Co., Walsrode, Germany		
Kernlon...	C	Add: Galalith, Ltd., London	Piaphan...	P	Polymer...	UF, m	Zellhaut...	P	Chem. Fab. Heyden, Dresden		
Kerit*	C, F		Piaphan...	P	Polymer...	UF, m					

# NEWS OF THE INDUSTRY

Society developments of month included meeting of American Chemical Society at Denver, announcement of program for The Electrochemical Society meeting at Cleveland, and proposal of the Technical Association of the Pulp and Paper Industry to draw up specifications for steel castings



## Meetings of Chemical and Technical Societies

The Electrochemical Society will hold its sixty-second meeting at the Hotel Cleveland, Cleveland, Sept. 22-24. The Electrodeposition Division with Charles H. Eldridge as chairman will conduct the session on Sept. 22 with 12 papers scheduled for presentation. In the afternoon a trip will be made to the plant of the National Carbon Co. and a dinner-dance will be held in the evening.

On Sept. 23 a session on electro-organic chemistry will be conducted by Prof. Alexander Lowry. Eleven papers have been prepared for this session. At luncheon, there will be a round-table discussion on "The Electrochemical Industries at Hoover Dam." In the afternoon a visit will be paid to the plant of the General Electric Co. Following dinner a lecture on "Visible Sound" will be delivered by Prof. Dayton C. Miller.

A symposium on photo-electricity will open on Sept. 24 under the direction of Prof. Herman Schlundt. The symposium will include the reading of eight papers. A trip to the Goodyear Zeppelin plant will complete the program.

With an attendance much larger than had been anticipated—registrations having reached a total of 916—the eighty-fourth meeting of the American Chemical Society opened at Denver on Aug. 22 and continued through Aug. 26.

Strengthening of industry to cope with the problems of the prosperity era which chemistry sees ahead, heartening results in the war on disease, advances in motor fuel research, improvement in agriculture and in mining, stronger safeguards of public health, new products for the world's markets, soil enrichment, preservation of the food supply, and constructive plans to improve science teaching in the schools and colleges were among the developments described.

The industries of the West were discussed, and promising fields of expansion indicated. Metals and metallurgical operations were a chief theme. The immense practical value in the field of metals and alloys of the most recent and most advanced concepts of pure physics and chemistry were pointed out.

For distinguished service to chemistry, the Priestley Medal was bestowed upon Dr. Charles Lathrop Parsons.

The Society prize of \$1,000 was presented to Dr. Oscar K. Rice, of the chemistry faculty of Harvard University.

During the past few years a considerable tonnage of chromium-nickel-iron castings of the 18-8 type have been used by the sulphite pulping industry. There has been some confusion on the part of both users and producers as to the proper composition and heat treatment for this service. To clarify this situation, the Materials of Construction Committee of the Technical Association of the Pulp and Paper Industry has been

studying the problem from three angles. First an examination of the literature on the alloys in question, second, a metallurgical examination of castings that failed in service, and third, the experience of producers of the alloys. On the basis of a questionnaire sent to producers the committee has prepared a proposed T.A.P.P.I. specifications for these castings for sulphite service.

At the Fall meeting of T.A.P.P.I. which opened at Holyoke, Mass., on Sept. 14 a symposium on these proposed specifications was scheduled which is expected to result in the presentation of standards for adoption at the annual meeting which will be held in February, 1933.

## National Committee Plans Plant Modernization

Industrial leaders, through a National Committee on Industrial Rehabilitation of which A. W. Robertson of Pittsburgh is chairman, have planned a movement to influence manufacturers to modernize their plants now. In announcing the plan Mr. Robertson said:

"The progress of industrial maintenance has been interrupted to such a degree that today more than 50 per cent of the machinery, equipment and plant facilities in American factories is obsolete," he continued. "The fact that in these last three years there has been more rapid improvement in equipment design than in any period in our industrial history makes the condition that much more urgent. Replacement has not kept pace with this engineering advance."

The importance of the program may be gleaned from the fact, Mr. Robertson explained, that along with the prostrating sag in employment, expenditures for equipment, machinery and plant facilities have dropped from an average normal annual outlay of \$5,000,000,000 to a yearly total of \$1,260,000,000.

## Titanium Co. Withdraws Bid for Salpa Plant

An offer made by the Titanium Pigment Co. to purchase the plant of the American Salpa Co. at Spotswood, N. J., was withdrawn on Aug. 26. The plant of American Salpa Co. was built three years ago by foreign interests to manufacture salpa, a leather composition. Fifteen months ago, the company was placed in the hands of receivers and the plant, comprising 21 buildings with equipment, was appraised at \$4,000,000. The offer made by the Titanium Pigment Co. was contingent on permission to use South River for disposal of waste which the State Department of Health refused to grant. The offer included \$100,000 cash payment and assuming mortgages of \$275,000.

**A**PPREHENSION regarding the effect that the Ottawa agreement may have on our largest export market for chemicals has been aggravated by a lack of precise knowledge of its terms. That Great Britain will cut into our trade with the Dominion is a foregone conclusion but ratification of the agreement in the latter part of October will reveal that it falls far short of giving the British a monopoly.

Many British products have received preferential treatment in Canada for years but American products have the great advantage of proximity to a market backed by advertising not only in the Dominion but in American media, many of which circulate as generally through Canada as in the United States. This constant appeal to consumers already sold on the quality and variety of American products should go far to hold trade against British goods whose principal bid for preference is a cheaper price.

The Ottawa agreement is not regarded in Washington as a signal to American exporters to rush into Canada and establish more branch plants but to increase sales promotion of products that already enjoy acceptance.

In helping Great Britain to undersell American products, Canada also is inviting competition with the products of its own industry, which it desires to foster. From this it may be assumed that the cut in favor of British goods will not be excessive. It is not likely either that existing trade alliances have been entirely ignored. Canadian Industries is controlled by Imperial Chemical Industries, Ltd., but duPont has an almost equally large interest in the Dominion enterprise.

#### Dominion Trade With United States

While U. S. chemicals dominate the Canadian market, totaling \$20,359,000 in the year ended last March, against Britain's share of \$4,096,000, the United States also is Canada's best customer, buying products to the value of \$4,123,000 as against British purchases during the same period of \$3,130,000. The importance of Canada in our import trade has advanced with the development of water power to produce electrochemicals. Calcium cyanamide and sodium cyanide, the principal items, are on the free list.

The highly finished products—paints and varnishes, toilet preparations and medicinals—of the American industry seem to hold an impregnable position in the Canadian market. Britain itself is a larger buyer of these articles than Canada. Canada stands first as a buyer of industrial chemicals, taking more than twice as much as either the United Kingdom or Germany, and first in the fertilizer trade. Canada takes almost all the calcium chloride exported, more than one-third of the synthetic organic chemicals as well as the largest quantities of agricultural insecticides and other specialties.

## NEWS FROM WASHINGTON

By PAUL WOOTON  
*Washington Correspondent  
of Chem. & Met.*



Great Britain offers some competition in sodium compounds and products of considerably lesser importance but there is little ground for fear that the Ottawa agreement will overwhelm this country's export trade. It is more likely to be disturbing because of its selective character. Representing a large variety, many of the individual items comprising our trade with Canada are of relatively small importance, although the total represented one-fifth of our entire chemical export trade last year.

There is some reason to believe that, as a sequel of the Ottawa conference, the British government will invite representation from non-empire countries into discussions for preferential terms under the Import Duties Act. Such an over-

ture may come to the American from the British chemical industry through the Association of British Chemical Manufacturers.

A comparison of the position occupied in the Canadian market by products of the United States and the United Kingdom during the 12-month period ended last March follows:

	From U. K.	From U. S.
Total	\$4,096,000	\$20,359,000
Stearic acid.....	55,000	21,000
Citric acid.....	84,000	1,700
Other acids.....	114,000	502,000
Cellulose products..	71,000	2,210,000
Drugs & medicinals .....	854,000	1,465,000
Dyes & tanning materials .....	275,000	2,019,000
Fertilizers .....	20,000	1,782,000
Explosives .....	40,000	290,000
Paints and varnishes .....	669,000	2,192,000
Inorganic chemicals	983,000	5,928,000

Chile's proposal to barter nitrate for wheat, in the wind for several weeks past, apparently has been squelched by the War Department's refusal to acquire some 40,000 tons as "military reserves." Present Army stocks are reported to amount to 80,000 tons. Nitrate of soda is no longer essential as a source of nitric acid for munitions as this is now derived from oxidation of ammonia. Cosach, on the other hand, declined to become a party to any exchange which might curtail the commercial market in the United States. The barter idea was sympathetically regarded by the Federal Farm Board but it felt that the exchange should be arranged through trade channels without its taking a hand.



First to Demonstrate Modern Explosives Via Radio

In a nation-wide broadcast to commemorate the birth on August 26, 1743, of Anton Laurent Lavoisier, Dr. H. C. Parmelee, vice-president and editorial director of the McGraw-Hill Publishing Co., and J. Barab, explosives engineer of the Hercules Powder Co., staged the first radio demonstration of the explosive action of black and smokeless powders, mercury fulminate and nitroglycerine. By using extremely small quantities of these materials, the demonstration was made without damage to the participants or the N.B.C. broadcasting facilities at Bound Brook, N. J. The city authorities would not grant permission to move even these small quantities of explosives through the bridges or through the tunnel into New York and on this account the program was staged at the New Jersey station of WJZ.

# MARKETS

Consuming industries took on larger supplies of chemicals last month but the output of chemicals was only slightly increased. Lower prices stimulated large contract placements of liquid chlorine. Nitrate of soda also suffered marked drop in value but general price trend was upward.

DIFFERENT consuming industries increased their takings of chemicals in August. This was especially true of the rayon trade and of the various lines of textile manufactures. The increase in demand apparently was largely met by withdrawals from stocks as production of chemicals, measured by consumption of electrical energy gained but slightly over that for the preceding month. The index number for chemical production in August was 110.1 compared with 109.1 for July. Some branches of the producing industry fell below their July rate and the inference is that stocks of chemicals in producers' hands were lower at the end of August than they were at the beginning of that month.

Nitrate of soda and chlorine furnished the principal developments in the market. A new price schedule for nitrate of soda was announced for August and September deliveries. Quotations were on a basis of \$22.40 a ton in bulk and

\$23.70 a ton in 200-lb. bags. These figures represented a sharp drop from the levels which had previously been quoted and it was rumored that upward revisions might follow for October forward positions.

#### Competition in Chlorine

Producers of chlorine were active in securing orders for delivery over next year. In the attempt to book contract orders, considerable competition developed and this resulted in price reductions with \$1.55 per 100 lb. finally reached for tank car lots. A large part of the consuming industry was reported to have covered requirements under the influence of the lower prices available.

The activity in chlorine aroused comment about alkali contracts with views varying between the belief that competition similar to that experienced in the chlorine market would be stimulated and the contrary opinion that low prices for chlorine would preclude any decline in quotations for alkalis.

While the outstanding price changes of the month were the declines in nitrate and chlorine quotations, the general price trend was firmer with advances in lead oxides, tin salts, copper sulphate, naval stores, vegetable oils and animal fats.

Declines in quotations for liquid chlorine and nitrate of soda were more than offset by increases in other chemicals, notably, turpentine, red lead, litharge, orange mineral, and tin salts. The weighted index number was slightly higher for the month.

#### Chem. & Met. Weighted Index of Chemical Prices

Base = 100 for 1927

This month .....	84.56
Last month .....	84.53
August, 1931 .....	86.26
August, 1930 .....	94.38

Declines in quotations for liquid chlorine and nitrate of soda were more than offset by increases in other chemicals, notably, turpentine, red lead, litharge, orange mineral, and tin salts. The weighted index number was slightly higher for the month.

tion by industries during the peak year of activity in 1929 and during 1931 as shown below, the figures representing 1,000 lb.:

#### CONSUMPTION OF CHINA WOOD OIL

Industry	1929	1931
Paint and varnish .....	88,586	72,853
Linoleum and oilcloth .....	5,963	7,303
Printers' ink .....	437	965
Miscellaneous industries .....	2,688	1,193
Total .....	97,474	82,314

#### German Salt Cake Duty Free

German salt cake used principally in the manufacture of kraft paper and to some extent in glass has been declared duty-free in a ruling by the Bureau of Customs. The Rhodes Alkali & Chemical Corporation, San Francisco, producers of sodium sulphate, had contended that this byproduct of German potash should be dutiable at \$3 per ton as anhydrous sodium sulphate under Par. 81 of the 1930 tariff, rather than duty-free as crude sodium sulphate or crude salt cake under Par. 1766. The domestic producers cited the fact that the German product contains no sulphuric acid but the Bureau held that this characteristic does not permit classification as anhydrous of a product which is otherwise comparable to crude salt cake. The Bureau also stated that the German product had been brought to the attention of Congress during the course of the tariff revision in 1930 but that no change had been made in wording that would exclude it from the free list.

After a long drawn out investigation the Treasury Department has finally confirmed charges that sulphate of ammonia from Poland, Germany and Belgium was being dumped on the American market. Assessments representing the difference between the home market value and the selling price in this country may reach \$150,000. The investigation into alleged dumping from Holland, from which imports have been very heavy this year, still is pending.

The Tariff Commission has called a hearing for Oct. 30 on a French application for a reduction in duty on fluorspar, both acid and metallurgical grades. The present tariff levies a duty of \$5.60 and \$8.40 per ton respectively. Duty on animal glue as of Sept. 17 is 20 per cent and 2½c. a lb.

#### Chem. & Met. Weighted Index of Prices for Oils and Fats

Base = 100 for 1927

This month .....	48.57
Last month .....	43.41
September, 1931 .....	51.28
September, 1930 .....	77.86

Price advances were almost general throughout the vegetable oil and animal fats list. Crude cottonseed oil advanced to 4c. a lb. and linseed oil to 6.1c. a lb. for carlots in cooperage. Tallow and greases moved upward proportionately.

# CURRENT PRICES

The following prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to Sept. 15.

## Industrial Chemicals

	Current Price	Last Month	Last Year
Acetone, drums, lb.	\$0.10 - \$0.11	\$0.10 - \$0.11	\$0.10 - \$0.11
Acid, acetic, 28%, bbl., cwt.	2.65 - 2.90	2.65 - 2.90	2.60 - 2.85
Glacial 99% tanks, drs.	8.89	8.89	8.98
U. S. P. reagent, chys.	9.14 - 9.39	9.14 - 9.39	9.23 - 9.48
Boric, bbl., lb.	9.64 - 9.89	9.64 - 9.89	9.73 - 9.98
Citric, kegs, lb.	.04 - .05	.04 - .05	.06 - .07
Formic, bbl., lb.	.29 - .31	.30 - .31	.35 - .36
Gallic, tech., bbl., lb.	.10 - .11	.10 - .11	.10 - .11
Hydrofluoric 30% carb., bbl.	.50 - .55	.50 - .55	.50 - .55
Latic, 44%, tech., light, bbl., lb.	.06 - .07	.06 - .07	.06 - .07
Muriatic, 18% tanks, light, bbl., lb.	.11 - .12	.11 - .12	.11 - .12
Muriatic, 18% tanks, cwt.	.05 - .06	.05 - .06	.05 - .06
Nitric, 36% carboys, lb.	.05 - .051	.05 - .051	.05 - .051
Oleum, tanks, wks., ton.	18.50 - 20.00	18.50 - 20.00	18.50 - 20.00
Oxalic, crystals, bbl., lb.	.11 - .111	.11 - .111	.11 - .12
Phosphoric, tech., chys., lb.	.081 - .09	.081 - .09	.081 - .09
Sulphuric, 60% tanks, ton.	11.00 - 11.50	11.00 - 11.50	11.00 - 11.50
Sulphuric, 66% tanks, ton.	15.50 - .	15.50 - .	15.50 - .
Tannic, tech., bbl., lb.	.23 - .35	.23 - .35	.23 - .35
Tartaric, powd., bbl., lb.	.22 - .23	.23 - .24	.27 - .28
Tungstic, bbl., lb.	1.40 - 1.50	1.40 - 1.50	1.40 - 1.50
Alcohol, ethyl, 190 p.f., bbl., gal.	2.53 - .	2.53 - .	2.33 - .
Alcohol, Butyl, tanks, lb.	.113 - .	.113 - .	.151 - .
Alcohol, Amyl, From Pentane, tanks, lb.	.182 - .	.182 - .	.203 - .
Denatured, 190 proof, No. 1 special dr., gal.	.34 - .	.34 - .	.28 - .
No. 5, 188 proof, dr., gal.	.381 - .	.381 - .	.28 - .
Alum, ammonia, lump, bbl., lb.	.03 - .04	.03 - .04	.03 - .04
Chrome, bbl., lb.	.04 - .05	.04 - .05	.04 - .05
Potash, lump, bbl., lb.	.03 - .04	.03 - .04	.03 - .04
Aluminum sulphate, com., bags, cwt.	1.25 - 1.40	1.25 - 1.40	1.25 - 1.40
Iron free, bg., cwt.	1.90 - 2.00	1.90 - 2.00	1.90 - 2.00
Aqua ammonia, 26%, drums, lbs.	.021 - .03	.021 - .03	.021 - .03
tanks, lbs.	.021 - .021	.021 - .021	.021 - .021
Ammonia, anhydrous, cyl., lbs.	.15 - .151	.15 - .151	.15 - .151
tanks, lbs.	.051 - .	.051 - .	.051 - .
Ammonium carbonate, powd., tech., casks, lbs.	.10 - .11	.10 - .11	.10 - .11
Sulphate, wks., cwt.	1.00 - .	1.00 - .	1.30 - .
Amylacetate tech., tanks, lbs., gal.	.16 - .	.16 - .	.172 - .
Antimony Oxide, bbl., lb.	.07 - .08	.06 - .08	.08 - .09
Arsenic, white, powd., bbl., lb.	.04 - .041	.04 - .041	.04 - .041
Red, powd., kegs, lb.	.09 - .10	.09 - .10	.09 - .10
Barium carbonate, bbl., ton.	56.50 - 58.00	56.50 - 58.00	56.50 - 58.00
Chloride, bbl., ton.	63.00 - 65.00	63.00 - 65.00	63.00 - 65.00
Nitrate, cask, lb.	.07 - .071	.07 - .071	.07 - .071
Blanc fixe, dry, bbl., lb.	.031 - .04	.031 - .04	.031 - .04
Bleaching powder, f.o.b., wks., drums, cwt.	1.75 - 2.00	1.75 - 2.00	2.00 - 2.10
Borax, grain, bags, ton.	40.00 - 45.00	40.00 - 45.00	50.00 - 57.00
Bromine, cs., lbs.	.36 - .38	.36 - .38	.36 - .38
Calcium acetate, bags.	2.50 - .	2.50 - .	2.00 - .
Arsenate, dr., lb.	.051 - .061	.051 - .061	.06 - .07
Carbide drums, lb.	.05 - .06	.05 - .06	.05 - .06
Chloride, fused, dr., wks., ton.	18.00 - .	18.00 - .	20.00 - .
flake, dr., wks., ton.	21.00 - .	21.00 - .	22.75 - .
Phosphate, bbl., lb.	.08 - .081	.08 - .081	.08 - .081
Tetrachloride drums, lb.	.061 - .07	.061 - .07	.061 - .07
Chlorine, liquid, tanks, wks., lb.	.0155 - .	.011 - .	.011 - .
Cylinders	.04 - .06	.04 - .06	.04 - .06
Cobalt oxide, cans, lb.	1.23 - 1.35	1.23 - 1.35	1.35 - 1.45

	Current Price	Last Month	Last Year
Copperas, bags, f.o.b. wks., ton.	13.00 - 14.00	13.00 - 14.00	13.00 - 14.00
Copper carbonate, bbl., lb.	.07 - .16	.07 - .16	.081 - .18
Cyanide, tech., bbl., lb.	.39 - .44	.39 - .44	.41 - .46
Sulphate, bbl., cwt.	3.00 - 3.25	2.75 - 2.90	3.60 - 3.75
Cream of tartar, bbl., lb.	.17 - .171	.17 - .171	.221 - .23
Diethylene glycol, dr., lb.	.14 - .16	.14 - .16	.14 - .16
Epsom salt, dom., tech., bbl., cwt.	1.70 - 2.00	1.70 - 2.00	1.70 - 2.00
Imp., tech., bags, cwt.	1.15 - 1.25	1.15 - 1.25	1.15 - 1.25
Ethyl acetate, drums, lb.	.10 - .10	.10 - .10	.07 - .07
Formaldehyde, 40%, bbl., lb.	.06 - .07	.06 - .07	.06 - .07
Furfural, dr., contract, lb.	.10 - .171	.10 - .171	.10 - .171
Fuel oil, crude, drums, gal.	1.10 - 1.20	1.10 - 1.20	1.10 - 1.20
Refined, dr., gal.	1.80 - 1.90	1.80 - 1.90	1.80 - 1.90
Glauber's salt, bags, cwt.	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Glycerine, c.p., drums, extra, lb.	.101 - .101	.101 - .11	.111 - .12
Lead:			
White, basic carbonate, dry casks, lb.	.061 - .	.061 - .	.071 - .
White, basic sulphate, sack, lb.	.06 - .	.06 - .	.071 - .
Red, dry, sack, lb.	.07 - .	.061 - .	.071 - .
Lead acetate, white crys., bbl., lb.	.10 - .11	.10 - .11	.10 - .11
Lead arsenate, powd., bbl., lb.	.091 - .14	.091 - .14	.10 - .14
Lime, chem., bulk, ton.	8.50 - .	8.50 - .	8.50 - .
Litharge, pwrd., cask, lb.	.06 - .	.05 - .	.061 - .
Lithophane, bags, lb.	.041 - .05	.04 - .05	.041 - .05
Magnesium carb., tech., bags, lb.	.051 - .06	.051 - .06	.06 - .061
Methanol, 95%, tanks, gal.	.33 - .	.33 - .	.33 - .
97%, tanks, gal.	.34 - .	.34 - .	.34 - .
Synthetic, tanks, gal.	.351 - .	.351 - .	.371 - .
Nickel salt, double, bbl., lb.	.101 - .11	.101 - .11	.101 - .11
Orange mineral, cask, lb.	.091 - .	.09 - .	.091 - .
Phosphorus, red, cases, lb.	.42 - .44	.42 - .44	.42 - .44
Yellow, cases, lb.	.28 - .32	.31 - .32	.31 - .32
Potassium bichromate, casks, lb.	.08 - .081	.08 - .081	.09 - .091
Carbonate, 80-85%, calc. cask, lb.	.05 - .05	.05 - .05	.051 - .06
Chlorate, pwrd., lb.	.08 - .081	.08 - .081	.08 - .081
Hydroxide (c'stic potash) dr., lb.	.061 - .061	.061 - .061	.061 - .061
Muriate, 80% bags, ton.	37.15 - .	37.15 - .	37.15 - .
Nitrate, bbl., lb.	.051 - .06	.051 - .06	.051 - .06
Permanganate, drums, lb.	.16 - .161	.16 - .161	.16 - .161
Prussiate, yellow, casks, lb.	.181 - .191	.181 - .191	.181 - .191
Sal ammoniac, white, casks, lb.	.041 - .05	.04 - .05	.041 - .05
Salsoda, bbl., cwt.	.90 - .95	.90 - .95	.90 - .95
Salt cake, bulk, ton.	13.00 - 15.00	13.00 - 15.00	16.00 - 18.00
Soda ash, light, 58%, bags, contract, cwt.	1.15 - .	1.15 - .	1.15 - .
Soda, caustic, 76%, solid, drums, contract, cwt.	1.171 - .	1.171 - .	1.171 - .
Chloride, dr., lb.	2.50 - 2.75	2.50 - 2.75	2.50 - 2.75
Bicarbonate, bbl., cwt.	.05 - .06	.05 - .06	.05 - .051
Bichromate, casks, lb.	1.85 - 2.00	1.85 - 2.00	1.85 - 2.00
Bisulphite, bulk, ton.	.05 - .06	.05 - .06	.07 - .071
Bisulphite, bbl., lb.	14.00 - 16.00	14.00 - 16.00	14.00 - 16.00
Chlorate, kegs, lb.	.051 - .071	.051 - .071	.051 - .071
Chloride, tech., ton.	12.00 - 14.75	12.00 - 14.75	12.00 - 14.00
Cyanide, cases, dom., lb.	.151 - .16	.151 - .16	.161 - .17
Fluoride, bbl., lb.	.071 - .08	.071 - .08	.071 - .08
Hyposulphite, bbl., lb.	2.40 - 2.50	2.40 - 2.50	2.40 - 2.50
Nitrate, bags, cwt.	1.22 - .	1.22 - .	2.05 - .
Nitrite, casks, lb.	.071 - .08	.071 - .08	.071 - .08
Phosphate, dibasic, bbl., lb.	2.55 - 2.75	2.55 - 2.75	.0265 - .03
Prussiate, yel. drums, lb.	.111 - .12	.111 - .12	.111 - .12
Silicate (30%), drums, cwt.	.60 - .70	.60 - .70	.60 - .70
Sulphide, fused, 60-62%, dr., lb.	.021 - .031	.021 - .031	.021 - .031
Sulphite, crys., bbl., lb.	.03 - .031	.03 - .031	.03 - .031
Sulphur, crude at mine, bulk, ton	18.00 - .	18.00 - .	18.00 - .
Chloride, dr., lb.	.031 - .04	.031 - .04	.05 - .06
Dioxide, cyl., lb.	.061 - .07	.061 - .07	.061 - .07
Flour, bag, cwt.	1.55 - 3.00	1.55 - 3.00	1.55 - 3.00
Tin bichloride, bbl., lb.	nom - .	nom - .	nom - .
Oxide, bbl., lb.	.28 - .	.251 - .	.271 - .
Crystals, bbl., lb.	.25 - .	.23 - .	.251 - .
Zinc chloride, gran., bbl., lb.	.061 - .061	.061 - .061	.061 - .061
Carbonate, bbl., lb.	.101 - .11	.101 - .11	.101 - .11
Cyanide, dr., lb.	.38 - .42	.41 - .42	.41 - .42
Dust, bbl., lb.	.041 - .06	.041 - .05	.051 - .06
Zinc oxide, lead free, bag, lb.	.051 - .	.051 - .	.061 - .
5% lead sulphate, bags, lb.	.051 - .	.051 - .	.061 - .
Sulphate, bbl., cwt.	3.00 - 3.25	3.00 - 3.25	3.00 - 3.25
<b>Oils and Fats</b>			
Castor oil, No. 3, bbl., lb.	\$0.091 - \$0.101	\$0.091 - \$0.10	\$0.101 - \$0.11
Chinawood oil, bbl., lb.	.06 - .	.051 - .	.061 - .
Coconut oil, Ceylon, tanks, N. Y., lb.	.031 - .	.031 - .	.031 - .
Corn oil, crude, tanks, (f.o.b. mill), lb.	.041 - .	.031 - .	.051 - .
Cottonseed oil, crude (f.o.b. mill), tanks, lb.	.041 - .	.031 - .	.051 - .
Linseed oil, raw ear lots, bbl., lb.	.061 - .	.053 - .	.075 - .
Palm, Lagos, casks, lb.	.04 - .	.031 - .	.041 - .
Niger, casks, lb.	.031 - .	.031 - .	.041 - .
Palm kernel, bbl., lb.	.041 - .	.041 - .	.051 - .
Peanut oil, crude, tanks (mill), lb.	.061 - .	.051 - .	.071 - .
Rapeseed oil, refined, bbl., gal.	.041 - .	.041 - .	.041 - .
Soybean oil, tank (f.o.b. Coast), lb.	.041 - .	.041 - .	.041 - .
Sulphur (olive foots), bbl., lb.	.25 - .26	.25 - .26	.40 - .44
Cod, Newfoundland, bbl., gal.	.29 - .30	.30 - .32	.34 - .36
Menhaden, light pressed, bbl., gal.	.12 - .	.12 - .	.171 - .
Crude, tanks (f.o.b. factory), gal.	.12 - .	.12 - .	.171 - .
Grease, yellow, loose, lb.	.031 - .	.021 - .	.021 - .
Oleo stearine, lb.	.061 - .	.051 - .	.071 - .
Red oil, distilled, d.p. bbl., lb.	.061 - .	.061 - .	.071 - .
Tallow, extra, loose, lb.	.031 - .	.021 - .	.031 - .

## Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-naphthol, crude, bbl., lb.	\$0.60 - \$0.65	\$0.60 - \$0.65	\$0.60 - \$0.62
Refined, bbl., lb.	.80 - .85	.80 - .85	.80 - .85
Alpha-naphthylamine, bbl., lb.	.32 - .34	.32 - .34	.32 - .34
Aniline oil, drums, extra, lb.	.14 - .15	.14 - .15	.15 - .16
Aniline salts, bbl., lb.	.24 - .25	.24 - .25	.24 - .52
Benzaldehyde, U.S.P., dr., lb.	\$1.10 - \$1.25	\$1.10 - \$1.25	\$1.10 - \$1.25
Benzidine base, bbl., lb.	.65 - .67	.65 - .67	.65 - .67
Benzoic acid, U.S.P., kgs, lb.	.48 - .52	.48 - .52	.57 - .60
Benzyl chloride, tech., dr., lb.	.30 - .35	.30 - .35	.30 - .35
Benzol, 90%, tanks, works, gal.	.20 - .21	.20 - .21	.20 - .21
Beta-naphthol, tech., drums, lb.	.22 - .24	.22 - .24	.22 - .24
Cresol, U. S. P., dr., lb.	.10 - .11	.10 - .11	.14 - .17
Cresylic acid, 97%, dr., wks, gal.	.49 - .52	.49 - .52	.54 - .58
Diethylamine, dr., lb.	.55 - .58	.55 - .58	.55 - .58
Dinitrophenol, bbl., lb.	.29 - .30	.29 - .30	.29 - .30
Dinitrotoluene, bbl., lb.	.16 - .17	.16 - .17	.16 - .17
Dip oil 25% dr., gal.	.23 - .25	.23 - .25	.26 - .28
Diphenylamine, bbl., lb.	.38 - .40	.38 - .40	.38 - .40
H-acid, bbl., lb.	.65 - .70	.65 - .70	.65 - .70
Naphthalene, flake, bbl., lb.	.03 - .04	.03 - .04	.03 - .04
Nitrobenzene, dr., lb.	.08 - .09	.08 - .09	.08 - .10
Para-nitraniline, bbl., lb.	.51 - .55	.51 - .55	.51 - .55
Para-nitrotoluene, bbl., lb.	.26 - .28	.26 - .28	.29 - .31
Phenol, U.S.P., drums, lb.	.14 - .15	.14 - .15	.14 - .15
Pieric acid, bbl., lb.	.30 - .40	.30 - .40	.30 - .40
Pyridine, dr., lb.	1.50 - 1.75	1.50 - 1.80	1.50 - 1.80
R-salt, bbl., lb.	.40 - .44	.40 - .44	.40 - .44
Resorcin, tech., kgs, lb.	.65 - .70	.65 - .70	.15 - 1.25
Salicylic acid, tech., bbl., lb.	.33 - .35	.33 - .35	.33 - .35
Solvent naphtha, w.w., tanks, gal.	.26 - .28	.26 - .28	.25 - .30
Xolidine, bbl., lb.	.86 - .88	.86 - .88	.86 - .88
Toluene, tanks, works, gal.	.30 - .32	.30 - .32	.30 - .32
Tyrene, com., tanks, gal.	.26 - .28	.26 - .28	.25 - .28

## Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl., ton	\$22.00 - \$25.00	\$22.00 - \$25.00	\$23.00 - \$25.00
Casein, tech., bbl., lb.	.06 - .10	.06 - .10	.06 - .11
China clay, dom., f.o.b. mine, ton	8.00 - 20.00	8.00 - 20.00	8.00 - 20.00
Dry colors:			
Carbon black (wks.), lb.	.021 - .20	.021 - .20	.03 - .20
Prussian blue, bbl., lb.	.35 - .36	.35 - .36	.35 - .36
Ultramine blue, bbl., lb.	.06 - .32	.06 - .32	.06 - .32
Chrome green, bbl., lb.	.26 - .27	.27 - .28	.27 - .30
Carmine red, tins, lb.	3.90 - 4.50	3.90 - 4.50	5.00 - 5.40
Paras toner, lb.	.75 - .80	.75 - .80	.77 - .80
Vermilion, English, bbl., lb.	1.25 - 1.50	1.25 - 1.50	1.35 - 1.60
Chrome yellow, C. P., bbl., lb.	.16 - .16	.16 - .16	.16 - .17
Feldspar, No. 1 (f.o.b. N.C.), ton	6.50 - 7.50	6.50 - 7.50	6.50 - 7.50
Graphite, Ceylon, lump, bbl., lb.	.07 - .08	.07 - .08	.07 - .08
Gum copal Congo, bags, lb.	.06 - .08	.06 - .08	.07 - .09
Manila, bags, lb.	.16 - .17	.16 - .17	.16 - .17
Damar, Batavia, cases, lb.	.16 - .16	.16 - .19	.16 - .16
Kauri No. 1 cases, lb.	.45 - .48	.45 - .48	.48 - .53
Kieselguhr (f.o.b. N.Y.), ton	50.00 - 55.00	50.00 - 55.00	50.00 - 55.00
Magnesite, calc. ton	40.00 - .00	40.00 - .00	40.00 - .00
Pumice stone, lump, bbl., lb.	.05 - .07	.05 - .08	.05 - .07
Rosin, H., bbl.	.03 - .40	.03 - .40	.03 - .35
Turpentine, gal.	4.30 - .00	3.65 - .00	4.25 - .00
Shellac, orange, fine, bags, lb.	.46 - .47	.46 - .47	.38 - .40
Bleached, bonedry, bags, lb.	.20 - .25	.20 - .25	.38 - .40
T. N. bags, lb.	.18 - .19	.16 - .17	.28 - .30
Soapstone (f.o.b. Vt.), bags, ton	10.00 - 12.00	10.00 - 12.00	10.00 - 12.00
Talc, 200 mesh (f.o.b. Vt.), ton	8.00 - 8.50	8.00 - 8.50	9.50 - .00
300 mesh (f.o.b. Ga.), ton	7.50 - 10.00	7.50 - 10.00	7.50 - 11.00
225 mesh (f.o.b. N.Y.), ton	13.75 - .00	13.75 - .00	13.75 - .00
Wax, Bayberry, bbl., lb.	.16 - .20	.16 - .20	.19 - .22
Bee蜡, ref., light, lb.	.20 - .30	.25 - .27	.26 - .27
Candelilla, bags, bags, lb.	.11 - .12	.11 - .12	.13 - .14
Carnauba, No. 1, bags, lb.	.21 - .23	.21 - .23	.35 - .36
Paraffine, crude	.03 - .03	.03 - .04	.03 - .03
105-110 m.p., lb.			

## Price Changes During Month

Advanced	Declined
Copper sulphate	Citric acid
Turpentine	Tartaric acid
Rosin	Chlorine
Tin salts	Nitrate of soda
Lead oxides	
Linseed oil	
Cottonseed oil	
Tallow	

## Ferro-Alloys

	Current Price	Last Month	Last Year
Ferrotitanium, 15-18%, ton	\$200.00-	\$200.00-	\$200.00-
Ferromanganese, 78-82%, ton	68.00-	68.00-	80.00-85.00
Ferrochrome, 65-70%	.10-	.10-	.11-
Spiegeleisen, 19-21%, ton	25.00-	25.00-	30.00-
Ferrosilicon, 14-17%, ton	31.00-	31.00-	39.00-
Ferrotungsten, 70-80%, lb.	1.00 - 1.10	1.00 - 1.10	1.00 - 1.10
Ferrovandium, 30-40%, lb.	3.05 - 3.40	3.05 - 3.40	3.15 - 3.50

## Non-Ferrous Metals

	Current Price	Last Month	Last Year
Copper, electrolytic, lb.	\$0.061-	\$0.051-	\$0.071-
Aluminum, 96-99%, lb.	.229-	.229-	.233-
Antimony, Chin. and Jap., lb.	.055-	.05-	.0665-
Nickel, 99%, lb.	.35-	.35-	.35-
Monel metal blocks, lb.	.28-	.28-	.28-
Tin, 5-ton lots, Straits, lb.	.253-	.214-	.251-
Lend, New York, spot, lb.	.036-	.031-	.044-
Zinc, New York, spot, lb.	.0382-	.0312-	.0415-
Silver, commercial, oz.	.281-	.284-	.28-
Cadmium, lb.	.55-	.55-	.55-
Bismuth, ton lots, lb.	.85-	.85-	1.50-
Cobalt, lb.	2.30-	2.30-	2.30-
Magnesium, ingots, 99%, lb.	.30-	.30-	.48-
Platinum, ref., oz.	35.00-	35.00-	40.00-
Palladium, ref., oz.	18.00 - 19.00	18.00 - 19.00	19.00 - 21.00
Mercury, flask, 75 lb.	47.00 - 48.00	48.50 - .	80.00 -
Tungsten powder, lb.	1.45 -	1.45 -	1.65 -

## Ores and Semi-finished Products

	Current Price	Last Month	Last Year
Bauxite, crushed, wks., ton	\$6.50 - \$8.25	\$6.50 - \$8.25	\$6.50 - \$8.25
Chrome ore, c. f. post, ton	16.50 - 19.00	16.50 - 19.00	19.50 - 24.00
Coke, fdry., f.o.b. ovens, ton	3.25 - 3.75	3.25 - 3.75	3.25 - 3.75
Fluorspar, gravel, f.o.b. Il., ton	17.25 - 20.00	17.25 - 20.00	17.25 - 20.00
Manganese ore, 50% Mn., e.i.f.			
Atlantic Ports, unit	.23 -	.23 -	.25 - .27
MoS <sub>2</sub> , N. Y., lb.	.45 -	.45 -	.35 - .40
Monazite, 6% ThO <sub>2</sub> , ton	60.00 -	60.00 -	60.00 -
Pyrites, Span., fines, c.i.f., unit	.13 -	.13 -	.13 -
Rutile, 94-96% TiO <sub>2</sub> , lb.	.10 - .11	.10 - .11	.10 - .11
Tungsten, scheelite, 60% WO <sub>3</sub> and over, unit	9.00 - 10.50	9.00 - 10.50	11.25 - 12.00

## INDUSTRIAL NOTES

AMERICAN MACHINE AND METALS, INC., through its president, P. G. Mumford, has announced that its subsidiary, the Tolhurst Machine Works, Inc., has purchased Sweet & Doyle Foundry & Machine Co. of Green Island, Troy, N. Y.

THE FALK CORPORATION, Milwaukee, has appointed L. A. Graham, sales manager, and M. A. Carpenter, sales promotion manager, for all commercial products of the corporation.

A. M. CASTLE & Co. has been appointed distributor of the Babcock & Wilcox Tube Co.'s products in Chicago and Pacific Coast territories.

R. T. VANDERBILT Co., New York, offers a new solvent-intensifier, called Bondogen, for use in rubber-solvent cements and spreader doughs.

FOOTE BROS. GEAR AND MACHINE CO. is now represented in Denver, Colo., by Urquhart Service. Briggs Schaffner now represent the Foote company in North Carolina and South Carolina. Manufacturing operations of the Foote company will be consolidated at the Plamondon Division.

THE KOPPERS CONSTRUCTION CO. of Pittsburgh has acquired control of the Hiller Engineering & Construction Co., designers and manufacturers of refuse incinerator plants.

ALCO PRODUCTS, INC., is serving in an advisory capacity in construction of an absorption and stabilization plant to be installed in the Montreal refinery of the Shell Oil Co. of Canada, Ltd.

ATLAS ELECTRIC DEVICES Co., Chicago, has developed a new Fade-ometer to meet

testing requirements of the present standards of color fastness.

SWENSON EVAPORATOR CO., Harvey, Ill., has appointed L. C. Cooley as sales representative for Chicago and surrounding territory.

GLYCO PRODUCTS COMPANY, INC., Brooklyn, N. Y., has appointed Harold W. Feuchter sales representative for the company in the Buffalo district. Mr. Feuchter was formally research chemist for the National Aniline & Chemical Co.

GENERAL REFRACTORIES CO., Philadelphia, announces it will handle Carbex commodities manufactured by the McLeod & Henry Co. of Troy, N. Y.

MAGNETIC MANUFACTURING CO., Milwaukee, is now represented in the Dallas, Tex., territory by C. G. Unlaub.

# NEW CONSTRUCTION

## Where Plants Are Being Built in Process Industries

	This Month		Year to Date	
	Proposed Work and Bids	Contracts Awarded	Proposed Work and Bids	Contracts Awarded
New England.....	\$80,000	\$77,000	\$1,450,000	\$297,000
Middle Atlantic.....	200,000	181,000	2,790,000	5,171,000
Southern.....	40,000	55,000	1,395,000	549,000
Middle West.....	355,000	29,000	1,683,000	2,063,000
West of Mississippi.....	2,570,000	..	18,527,000	1,355,000
Far West.....	150,000	290,000	2,315,000	891,000
Canada.....	215,000	2,040,000	9,695,000	7,655,000
Total.....	\$3,610,000	\$2,672,000	\$37,855,000	\$18,021,000

## PROPOSED WORK BIDS ASKED

**Alumina Sulphate**—City will receive bids until Sept. 20 for furnishing and delivering 1,000 tons basic alumina sulphate. G. M. Shepard is city engineer.

**Asbestos Plant**—Prolac Ltd., Lachine, Que., plans to construct a 2 story addition to its asbestos plant. Estimated cost \$40,000.

**Alcohol Plant**—Rossville Commercial Alcohol Corp., Lawrenceburg, Ind., plans to construct a plant here. Estimated cost \$200,000. Maturity indefinite.

**Chemical Plant**—Valley Chemical Works, Carlstadt, N. J., plans to rebuild part of plant recently damaged by fire.

**Clay Mill**—Richmond Clay Products Corp., 9th St. Rd., Richmond, Va., plans to rebuild its clay mill recently destroyed by fire. Estimated cost \$40,000.

**Distilling Plant**—Owner, c/o Government El Salvador, San Salvador, C. A., plans to construct a distilling plant to have an annual capacity of 3,000,000 liters of beverage alcohol and 3,000,000 liters motor alcohol.

**Ethyllizing System**—Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until Sept. 21 for steel tanks, concrete ethyllizing plant enclosure, motor operated pumps, fan and piping and ethyllizing system at Naval Fleet Air Base, Coco Solo, C. Z.

**Flavoring Extracts Plant**—Wyss Manufacturing Co., 3640 20th St., San Francisco, Calif., plans to rebuild part of plant recently damaged by fire. Estimated cost to exceed \$60,000.

**Gas Plant**—Grand Rapids Gas Light Co., Grand Rapids, Mich., plans to construct an addition to its plant, including purifiers, etc. Estimated cost \$35,000.

**Cotton Oil Plant**—Security Cotton Oil Co., Texarkana, Ark., plans to construct a cotton oil plant at Rose Hill, Ark. Maturity indefinite.

**Lime Mill**—Rockland-Rockport Lime Co., Rockland, Me., plans to construct a hydrated lime mill. Estimated cost \$80,000.

**Lubricating Plant**—Sands Lubricants Co., 37-18 22nd St., Long Island City, N. Y., has leased a 50 x 180 ft. lot and building and will equip same for the manufacture of lubricants. Equipment, including tanks, will be purchased.

**Oil Refinery**—H. Foster & Co., Ltd., Leeds, England, plans to rebuild oil refinery, including condensing unit. Estimated cost \$100,000.

**Oil Refinery**—Gulf Refining Co., W. M. Bray Brooks, Asst. Gen. Mgr., Forest and Western Ave., Gulfport, S. I., N. Y., plans to build 2 story oil refinery, including administration buildings. Estimated cost \$40,000.

**Refinery**—Sinclair Refining Co., 45 Nassau St., New York, N. Y., plans extensions to its plants at Houston, Tex., and Coffeyville, Kan. This is part of \$2,500,000 construction program contemplated by company.

**Paper Plant**—Union Socialist Soviet Republics, c/o Amtorg Trading Corp., 261 5th Ave., New York, N. Y., plans to construct a paper plant to have an annual capacity of 25,000 tons at Ingurak, between Sukhum and Batum on the Black Sea, Soviet Russia.

**Paint Factory**—Baker Paint & Varnish Co., C. J. Hoffman, Pres., 228 Suydam Ave., Jersey City, N. J., plans to rebuild its factory here, recently destroyed by fire. Estimated cost \$40,000.

**Paint Factory**—Dixie Paint Co., c/o W. B. Russell, 2544 Elm St., Dallas, Tex., plans to rebuild part of plant damaged by fire. Estimated cost \$40,000.

**Paint Warehouse**—Certain-Teed Products Corp., 595 South 21st St., Irvington, N. J., plans to rebuild warehouse on South 20th St., recently destroyed by fire. Estimated cost \$40,000.

**Paper Plant**—Wheeler Estate, Peoria, Ill., plans to construct a storage and manufacturing building at Peoria to be leased to Klock & Juhl Co. and Blair Paper Co. Estimated cost \$40,000. Maturity indefinite.

**Pottery Plant**—L. P. Reese, New Cumberland, W. Va., recently purchased Scio pottery plant, Scio, Ohio, and will install new tunnel kiln with new building to house it. Plant has been inactive for several years. Estimated cost \$40,000.

**Pottery Plant**—Solar Corporation, Beaver Dam, Wis., plans to build a pottery plant here. Estimated cost \$40,000.

**Tile Manufacturing Plant**—Pauly Manufacturing Co., A. A. Pauly, Pres., 1333 K St., N. W., Wash., D. C., plans to construct a 1 and 2 story plant for the manufacture of tile at Erie, Pa. Estimated cost \$50,000.

**Radium Extractor Plant**—Eldorado Gold Mines, Ltd., Port Hope, Ont., have acquired a factory building and will install equipment for commercial scale radium extraction. Estimated cost \$175,000.

**Rayon Plant**—Imperial Rayon Co., Tokyo, Japan, plans to improve and enlarge its plant at Iwakuni, Japan. Estimated cost \$175,000.

**Yeast Manufacturing Plant**—Fleischmann Co. of California, 245 11th St., San Francisco, Calif., plans to construct a plant at Oakland, Calif. Estimated cost \$100,000.

## CONTRACTS AWARDED

**Brake Lining Plant**—Canadian Raybestos Co., Perry St., Peterborough, Ont., awarded contract for 1 and 2 story, 60 x 150 ft. and 35 x 60 ft. addition to plant for manufacture of brake linings to T. A. Brown, 1121 Day St., Toronto, Ont. Estimated cost \$40,000.

**Fibreboard Box Plant**—Gulf States Crate Co., Inc., H. S. Weigel, Pres., Amitie, La., will build a plant for the manufacture of fiberboard strawberry containers. Work will be done with local labor.

**Chemical Plant**—Monsanto Chemical Works, 1724 South 2nd St., St. Louis, Mo., awarded contract for addition to plant at Rubion, North Wales, England, including power plant and storage and distribution facilities, to Metropolitan Vickers Co., London, England. Estimated cost \$350,000.

**Chemical Plant**—Pfister Chemical Co., Inc., c/o C. T. Lansing, 67 North Dean St., Englewood, N. J., awarded contract for 2 story chemical manufacturing plant opposite Morse-Mere R.R. station, Ridgefield, N. J., to William J. Lange, Inc., 1025 Hoyt St., Ridgefield, N. J. Estimated cost \$27,750.

**Molybdenum Mill**—Chimax Molybdenum Co., 295 Madison Ave., New York, N. Y., awarded contract for mill at Langlois, Pa., to Rust Engineering Co., Koppers Bldg., Pittsburgh, Pa. Estimated cost \$50,000.

**Dye Plant**—Apex Piece Dye Works, 155 Sherman Ave., Paterson, N. J., awarded contract for 2 story addition to plant to Samworth-Hughes Co., 177 Van Houten St., Paterson. Estimated cost \$27,750.

**Gas Purifier**—New York & Richmond Gas Co., 691 Bay St., St. George, S. I., awarded contract for 32 x 32 ft. gas purifier at Willow Ave. and Bay St., St. George, to Semet-Solvay Engineering Co., 61 Bayway, New York, N. Y.

**Glass Factory**—Pittsburgh Plate Glass Co., 1915 Madison Ave., Indianapolis, Ind., is building a plant at 57 South State Ave., Indianapolis, by company forces. Estimated cost \$29,000.

**Glass Storage Warehouse**—Glenshaw Glass Co., George Meyer, Secy., Glenshaw, Pa., awarded contract for warehouse on Butler Plank Rd., to Pittsburgh Engineering Foundry & Construction Co., 39th St. and Railroad Ave., Pittsburgh, Pa.

**Leather Factory**—J. S. Barnet & Sons, Inc., 128 Boston St., Lynn, Mass., awarded contract for 3 story factory on Boston St. to Campbell Bros., 100 Sagamore St., Lynn. Estimated cost including machinery \$40,000.

**Leather Factory**—England, Walton & Co., Waynesville, N. C., awarded contract for 50 x 100 ft. addition to factory at Hazelwood, N. C., to Jerry Liner, Lake Junaluska, N. C.

**Magazine Buildings**—Bureau of Yards & Docks, Navy Dept., Wash., D. C., awarded contract for improving three magazine buildings at Fort Mifflin, Pa., to Robbins Contracting Co., 1137 North Front St., Philadelphia. Estimated cost \$35,281.

**Gasoline Absorption and Stabilizing Plant**—Utah Oil Refining Co., E. S. Holt, Pres., Newhouse Bldg., Salt Lake City, Utah, is having plans prepared for a gasoline absorption and stabilizing plant. Work will be done by day labor. Estimated cost \$250,000.

**Refinery**—Shell Oil Co. of Canada, Ltd., 276 St. James St. W., Montreal, Que., awarded contract for 23 tanks for proposed new refinery at Montreal to Toronto Iron Works, Eastern Ave., Toronto, Ont. Estimated cost of entire project \$2,000,000.

**Soap Factory**—Lever Bros., Inc., 164 Broadway, Cambridge, Mass., awarded contract for superstructure of 2 story, 31 x 84 ft. factory and office addition to Vappi & Ferguson Co., Inc., 260 Sydney St., Cambridge. Estimated cost of entire project \$37,000.

**Steel Mill, Laboratory, etc.**—Columbia Steel Corp., Border St., Torrance, Calif., is building an addition to its steel mill, including a chemical laboratory, warehouse and office. Work is being done by owner's construction department. Estimated cost \$40,000.